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SOILS OF EASTERN TIBET AND THEIR DISTRIBUTION PATTERN

S. V. ZONN, Forest Science Laboratory, Academy of Sciences, USSR

Information about the soils of Tibet is exremely meager. They might be represented as unique desert, dry-steppe and meadow soils ound widely distributed over high plateaus and ridges, but such a description would not reflect he diversity of soil groups undergoing formaion in various parts of Tibet, nor would it reveal the specific character of soil formation at elevations from three to four thousand meters.

In terms of its soil, Tibet is a unique region where altitude affects bioclimatic factors to an extent that causes soil formation processes to differ substantially from those normally encountered.

While, undoubtedly, altitude causes modifications in bioclimatic factors of soil formation, t does not necessarily affect certain propeies of soils indigenous to the latitudes in which he territory lies. More probably, a certain ransformation of these features is due to quanitative and qualitative variations in solar radiation.

In this respect north Tibet differs sharply rom the south. In the former, the vegetation and soils, for all their uniqueness, exhibit eatures of the temperate, cold zone, while in he latter, certain features typical of the subropical bioclimatic zone are found. The N'enchen-Tongla range in the west and the north spurs of the Sino-Tibetan Alps in the center apparently form the orographic boundary between hese zones.

Such differences in nature and tendency of oil-forming processes agree with the accepted lassification of Tibet into "forest" and "steppe" oils. This classification is based on the preominance in the south of large canyon and isoated forests, and in the north where they are ot encountered, on the prevalence of various ypes of grass vegetation. Farming is the rincipal form of agriculture activity in the outh, while livestock production predominates n the north.

The soil was studied in 1958 by a Soviet-Chinese expedition[1] who conducted their work in the Abo Autonomous Okrug, which occupies the extreme eastern Tibetan plateau and the mountain massifs of the central Sino-Tibetan Alps. In the past this part of China was known as the Kam region.

The territory lies in the basin of two rivers — the Mintszian on the east and the Dadukhe on the west or, more exactly, along their tributaries, the Somokhe, Vantslantsygor, Lyaysugou, Tsakole and other rivers. The area is characterized by elevations of from 2300-6000 m and average slopes of 30° -40°. Only the north has a more gentle, peneplain- and plateau-type relief at an elevation of 3500-4500 m with mountain ranges, as it were, on it. The relief varies between 200 and 500 m.

The district was inaccessible until 1952 when the first road was constructed across it from east to west. Our foot routes crossed centuries-old virgin forests and alpine meadows at elevations of 2600-4100 m.

Data collected shed light on certain problems of the genesis and vertical-zonal distribution patterns of soils, and their interrelationships with individual formations and unique and unfamiliar forest types.

The route started from Chendu, center of Sychuan' Province, and proceeded up the Mintszian River. For the first 180-200 km to Venchan, the road passed through a moist, subtropical zonal, then entered a broad mountain basin; along the slopes subtropical, semidesert conditions were well defined at elevations ranging from 1500-2200 m. Xerophytic, semi-shrubby vegetation was found on low-humus, calcareous soils of the gray cinnamon-brown group. The mountain-forest zone extended from 2300 to 3800-4000 m. At higher elevations it was replaced by alpine meadows, rocks and snow.

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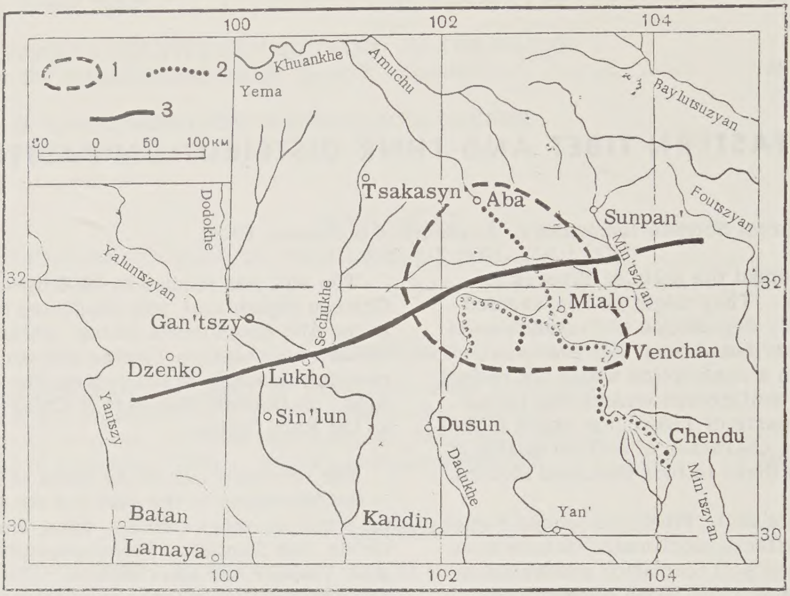
[1] The expedition was organized by the Forest Management Academy of the Forest Management Ministry of the KNR (Chinese Peoples' Republic). The author of the article was the soil group leader.



Schematic map of the 1958 work area in Eastern Tibet

1 - Boundaries of the study area; 2 - Main route; 3 - Boundary between the "steppe" and "forest" sections of Tibet.

Information on the climate exists for the river valleys only. Data from the villages of Maerkan (elevation 2600 m), located in the middle of the Somokhe and Lyaysugou River valleys respectively, show that their climatic conditions differ considerably (Table 1). In Maerkan the climate is warmer than in Mialo, where evaporation and snow depth are somewhat reduced. In Maerkan the annual precipitation varies between 665 and 912 mm. Maximum precipitation occurs during the summer-autumn period, the minimum in winter and spring, indicating the monsoon nature of the moisture cycle. The same precipitation occurs throughout the whole territory independently of elevation. Thus at Lunzhiba goskhoz, which is north of the city of Shadinsy located on a plateau (elevation 3530 m), the annual precipitation is as much as 1000 mm with the maximum from June to September. Snow reaches a depth of 10 cm in the depressions. The temperature regime at these elevations varies sharply. The average annual temperature is as low as 1° C, and the average maximum in July is not more than 10°C. From November to March the temperature is less than 0°C. Only 30-35 days a year are without frosts (end of June to middle of August) and this not every year. In Shadinsy, at an elevation of 3300 m, the absolute maximum temperature reaches 24°C in August and -25°C in January. During the day abrupt alternations of heat and cold occur. Thus, at 6 a.m. on July 13 the air temperature was from +1°-8°C, at 2 p.m., 25°-30°C, and at 4 p.m. it had dropped to 8°-10°C. North winds bring cold, rain and hail. In the north the growing season is no longer than 90 days; in the south, it may be as long as 200 days.

The climate of the exposed, high-mountai sections is colder than that of the deep mountain valleys where it depends on the orientation of the valleys and their proximity to massifs covered with glaciers and snow banks.

In Tibet there are sharp contrasts in the distribution of temperatures and moisture between individual sections of the territory and even greater contrast within these sections relative to the steepness and exposure of slopes.

Tibet is usually considered a country without forests covered with alpine grass vegetation. However, in the south, forests containi the following species of trees are rather wide distributed: spruce (Picea purpurea, P. asperata), hemlock (Tsuga chinensis), fir (Abie Faxoniana, A. recurvata, A. delavayi), juniper (Juniperus), pine (Pinus delavayi, P.

Table 1

Climatic characteristics of river valleys, by years

Climatic characteristics	Maerkan				Mialo
	1954	1955	1956	1957	1956
Average annual temperature	8.9	8.6	8.1	8.3	5.9
Maximum temperature	29.5	30.2	31.0	32.4	30.0
Minimum temperature	—12.6	—13.0	—12.7	—12.8	—16.0
Mean relative humidity, %	64	65	63	62	67
Maximum humidity, %	72—80	72—80	73—76	74—77	78
Precipitation, mm	912	905	738	665	895
Evaporation, mm	1299	1301	1302	1262	1191
Snow depth, cm	8	2	2	6	6

nsata), larch (Larix potanini), birch (Betula bosinensis, B. playtyphylla), evergreen oak uercus semicarpifolia), as well as many rubs, the most common of which are: bamo (Sin arundinaria), and many species of ododendron ranging from tree-like species -10 m high to small trailing varieties. Bryoytes are the predominant vegetation on shaded opes and mixed-grasses, beach grass (Calaagrotis), etc. on sunny slopes.

The vertical distribution boundaries of the rious vegetation and forest types (in meters) re:

rid-subtropical semi-shrubs	1500-2300
oniferous-broadleaved forests	2300-2700
ruce forests	2700-3600
ir forests	3600-3800-3900
arse larch forests	3900-4100
hododendron thickets	3800-4050
lpine waste	3900-4300
liffs and perpetual snow	4300-6000

On slopes of south and east exposure these undaries are 100-200 m higher. Moreover, belt of virgin oak forests is clearly developed elevations between 2800 and 3000 m. When ruce forests bordering the oak were cut, the k spread widely into the spruce belt often as gh as the upper boundary of the spruce stands. ine and juniper forests are found occasionally small stands on sunny slopes and hemlock rests on the shaded slopes.

As we pass to the plateau, grass vegetation pidly replaces the forests. For the first 30- km forests occur in isolated patches growing the north slope ravines of the low ranges. ey then completely disappear, giving way to eppe-like meadows to elevations of from 3500-00 m where the alpine waste begins. The tter are characterized by low-growth vegetation which makes a sod with moss cushions as thick as 10-15 cm.

As we know, in the mountainous area of Europe and Asia Minor the timber line is at an elevation of 2600-2800 m. Forests begin at these altitudes and continue to 4000-4100 in Tibet. This is an indication of the unusual modification of climatic conditions, which in no way corresponds to that of the temperate latitudes.

The presence in spruce forests of bamboo undergrowth also demonstrates how the ecological environment in these forests differs from that of spruce stands with which we are familiar. Lastly, the vigorous development of tree-like rhododendrons shows that a more favorable growth environment exists for them here than under any other high mountainous conditions.

Among other peculiarities the unique composition of the ash from the needles and leaves of woody species, bamboo, grasses and moss is noteworthy (Table 2). The accumulation of SiO_2, Al_2O_3, CaO and, in some cases, of MnO in the needles and leaves of all woody species except bamboo is considerably lower, but that of P_2O_5 and K_2O is higher than is found in woody species growing on podzolic and other soils in the USSR. Only the oak accumulates significantly larger amounts of all the elements in its leaves in comparison both with other species and with oak in Russia. Bamboo has the greatest ash element deficiency. Therefore it is characterized as one of these plants having lowest nutrient requirements.

In comparison with woody vegetation, grass vegetation and mosses accumulate considerably larger amounts of the ash elements, particularly P_2O_3 and K_2O. Mosses are characterized

Table 2

Ash composition of green plant tissue[a], percentage of dried material (Eastern Tibet)

Profile No.	Sample designation	Ash content	SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	CaO	MgO	MnO	P_2O_5	K_2O	SO_3
21	Oak leaf litter	8.416	2.890	0.674	0.174	0.325	2.114	0.647	0.131	0.175	0.307	0.332
3	Birch leaf litter	3.163	0.266	0.266	0.025	0.008	0.953	0.298	0.053	0.233	0.673	0.373
1	Spruce needles	3.086	0.456	0.393	0.024	0.044	1.110	0.293	none	0.325	0.678	0.556
	Bamboo	2.106	0.728	0.264	0.029	0.110	0.354	0.042	"	0.125	0.571	0.297
	Grass vegetation	13.082	1.791	0.944	0.044	0.072	1.307	0.820	"	0.828	5.585	0.489
2	Fir needles	4.711	0.261	0.666	0.038	0.218	1.609	0.383	0.125	0.410	0.673	0.209
	Rhododendron leaves	3.673	0.178	0.270	0.023	0.057	1.330	0.346	0.064	0.199	0.651	0.175
	Moss	15.042	2.129	3.822	0.531	3.011	1.588	0.655	0.131	0.280	0.574	0.299
	Grass vegetation	7.034	1.279	0.695	0.141	0.133	1.179	0.267	0.055	0.421	2.746	0.467
61	Armanda pine needles	4.765	0.253	0.538	0.039	0.072	1.324	0.516	none	0.427	0.938	0.378
74	Hemlock needles	5.556	0.409	0.541	0.039	0.298	2.120	0.649	"	0.204	0.487	0.221
8	Larch needles	3.984	0.342	0.669	0.026	0.057	0.958	0.556	"	0.586	1.063	0.440

[a] Analyses: The ash, total, humus composition, oxalate extract, available iron, and Kirsanov analyses were made in the Forest Soil Science Laboratory of the Forest Institute, Academy of Sciences, USSR; remaining analyses were performed in the Soil Science Laboratory of the Institute of Forest Management in Peking.

by a high percentage of ash and large amount
of SiO_2, Fe_2O_3, Al_2O_3, CaO and MgO.

From the observed ash content of tree anc
shrub leaf litter it may be surmised that the
element cycle in the plant-soil system has
specific features.

The soil-forming parent material in the st
area is rather homogeneous and consists pri
cipally of the weathering products of Paleozo
shales. Only in the western section do grani
occur; limestones and sandstones occur spor
cally. In the river valleys the upper terrace
were formed by glacial deposits and overlaid
with moden alluvia and deluvia.

The weathering of mountain rocks is inten
sive in the forest zone as evidenced by a soil
depth of 60-80 cm (or sometimes more) on
slopes as steep as 40%. In the alpine zone
soil depths are even greater. Thus, for example, in Tsokusan Pass (elevation 4080 m)
the soils attain a depth of one meter. This
paradoxical pattern remains unexplained.

Soil covers the mountain slopes and peaks
to elevations of 4000-4200 m, and locally
higher. The soils at these altitudes are not
fragmental and are developed more fully thar
at elevations of from 2000-3000 m in the mou
tainous areas at our latitudes. These soils
are also characterized by the combination of
features and properties typical of both warm
and cold regions. The development of moss
and peat is combined with intensive accumula
tion of humus; there is extensive micro-aggr
gation with little accumulation of silica. The
formation of humus-illuvial horizons occurs
in the absence of podzolization. Acid soils
alternate with secondary-carbonate alkaline
soils, and so on.

The appearance of such soil properties is
associated with the effect of various types of
vegetation, especially with forests. Therefore, the soils are described below on the
basis of vegetative types.

Spruce forests soils are distributed at ele
vations of from 2700-3800 m. Here the natu
and tendency toward soil formation are determined by the different climatic conditions
and the hydrologic regime on slopes of varyi
exposures where various types of spruce for
grow.

Profile 6. Soils under spruce-grass-mix
ture on slopes of east or west exposure exhibit no signs of podzolization. The litter is
6 cm deep, the A horizon extends to a depth
of 19 cm; the B to 50 cm, the BC to 64 cm
and the CD to 115 cm. Horizon A is dark-g
with a cinnamon-brown tinge; the B horizon
brown-yellow with well-expressed, powdery
granular structure and clay loam texture an

ıe lower horizons are very rocky.

On slopes of north and northwest exposure p to elevations of 3600-3700 m spruce-bamboo egetation is most widespread. Here thick soils f the following structure are formed:

Profile 1.

$_0$' 0-3 cm	Layer of moss litter.
$_0$'' 2-9 cm	Dark, almost black, with cinnamon-brown tinge, moist, peaty, thoroughly decayed layer of litter.
$_1$ 9-24 cm	Black, moist, with clearly expressed fine-granular structure, isolated blocks and nutty; silty to clay loams with occasional rock fragment inclusions, extensively penetrated with bamboo roots; friable.
$_1$ 24-58 cm	Yellow with brown tinge, bright, stony-clay loams, extensively penetrated by bamboo roots; moist.
$_2$ 58-70 cm	Yellow, lighter than the B_1, silty stony-clay loams; moist.
D 70-112 cm	Yellow with grayish tinge, stony-gravelly-clay loams; wet.

On terminal moraine and alluvial fan slopes f no more than 15%-25% under moss-spruce egetation of site quality III-IV, unique peatnoss, gleyed soils of the following profile are leveloped:

$_0$ 0-20 cm	Living moss from 5-7 cm; at 12 cm moss litter; at 20 cm coarse humus, peats making an abrupt transition into the A_2 horizon.
$_2$ 20-30 cm	Whitish-pinkish, sharply differing from the A_0 and B_1 horizons, of a distinctly granular-nutty structure with well-developed gleying in the form of dark, azure spots. Abrupt transition into the B_1 horizon.
$_1$ 30-36 cm	Dark, almost black with cinnamon-brown tinge; slightly compacted, powdery; rarely penetrated by roots.
$_2$ 36-50 cm	Yellow with brownish-gray tinge, lighter than B_1, stony-gravelly, with indistinct blocky-granular structure.
D 50-80 cm	Gray-greenish from the color of the rocks; rocky with a small amount of gravelly-clay loam in the fractures.

The strongly developed A horizon has a dis- inct structure which is specific to the given onditions.

In the north section (Shadinsy district), where the spruce, sparse-forest shrub combination ascends to the lower boundary of the alpine zone, unique mountain-meadow-forest soils without indications of podzolization are developed. Such soils (Profile 33) are characterized by dark-cinnamon-brown coloring and a powdery-granular structure. They contain earthworms, an extended profile with gradual transitions, and a small amount of gravel. Their total thickness may amount to as much as 75-80 cm.

The described soils differ considerably in litter accumulation. Thus, Profile 6 soil contains 18.8 metric tons/ha; Profile 1, 26.2; and Profile 15, 74.3 metric tons/ha.

Litters differ significantly in ash composition (Table 3). The spruce, sparse-forest litter (Profile 33) contains the largest accumulation of Ca, Mg, P_2O_5 and SO_3; and the spruce-moss (Profile 15), the spruce-grass-mixture (Profile 6) and spruce-bamboo (Profile 1) litters follow in descending order. The last is richest in SiO_2, Fe_2O_3 and Al_2O_3. Spruce-moss litter has the lowest content of these ash substances.

It is not impossible that the ash composition of the litter is determined to a large degree by grass, moss and shrub vegetation rather than by the spruce. Thus, CaO content increases as we proceed from the spruce-bamboo to the spruce-grass-mixture and spruce, sparse-forest vegetation. Spruce-moss litter is an exception, there being a greater accumulation of CaO in it than in Profiles 6 and 1. Such a peculiarity in biological accumulation of ash elements by the litter is also reflected in the total chemical composition of soils (Table 3). When there is a significant total accumulation of Ca, a rather intensive leaching of Mg and especially Fe_2O_3 and Al_2O_3 occurs in the upper horizons. In some cases (Profiles 1 and 33) there is no accumulation of SiO_2 in the upper horizons, while in others accumulation is so clearly developed (Profile 15) that it is comparable only to podzolic or weakly-podzolized soils (Profile 6). At the same time, a high Fe_2O_3, Al_2O_3, CaO and MgO content is observed in those horizons where SiO_2 does accumulate. The quantities and nature of distribution of these substances probably indicates the predominance of biological accumulation over leaching processes, even where the formation of humus-illuvial horizons (Profile 15) is concerned.

The increased MgO content in the soils is noticeable. This is associated with the significant amounts of Paleozoic shales. Lastly, the high Al_2O_3 content in the lower horizons of all soils should be noted; this may be due to subsoil weathering.

The total analysis of the clay separate (Table 4) also corroborates the observed regu-

Table 3

Total analysis of the composition of spruce forest soils, percentages of absolute dry weight

Pro. No.	Forest type and site conditions of deposition	Depth, cm	Loss on ignition %	SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	CaO	MgO	MnO	P_2O_5	SO_3
6	Spruce-grass-mixture, elevation 3450 m, 42° slope	2—5	64.00	19.67	10.42	1.33	8.75	1.96	0.60	0.03	0.35	0.16
		8—17	12.16	61.69	22.96	4.56	18.23	1.17	0.62	0.01	0.17	0.16
		24—35	10.55	60.28	25.89	6.35	19.39	0.83	0.90	0.02	0.15	0.34
		42—48	10.92	59.85	26.23	6.35	19.69	0.88	0.93	0.02	0.18	0.45
		52—62	6.91	59.63	30.71	6.46	24.05	0.86	1.05	0.02	0.19	0.49
1	Spruce-bamboo, elevation 3340 m, 41° slope	0—2	40.38	41.57	13.14	2.63	10.24	1.16	0.52	0.01	0.29	0.24
		4—9	27.14	53.57	17.10	3.41	13.53	0.75	0.32	none	0.16	0.18
		12—20	16.83	60.50	20.14	4.29	15.75	0.60	0.41	"	0.09	0.03
		30—40	10.45	61.88	24.61	6.88	17.70	0.63	0.81	Tr.	0.02	0.04
		70—80	6.49	65.08	23.77	5.65	18.10	0.57	1.23	0.04	0.01	0.09
15	Spruce-moss, elevation 3590 m, 15° slope, N-E exposures	0—12	70.42	13.68	6.08	1.00	4.74	1.99	0.51	0.03	0.34	0.32
		12—20	72.99	12.65	6.10	1.25	4.56	1.24	0.42	Tr.	0.29	0.32
		21—28	11.90	64.83	21.26	3.78	17.33	0.72	0.78	none	0.16	0.18
		30—35	12.85	54.86	29.21	8.81	20.31	0.66	1.72	"	0.10	0.12
		36—46	14.79	52.86	30.35	7.38	22.80	0.71	0.70	"	0.16	0.11
		50—60	15.37	52.95	26.71	6.81	19.72	0.77	1.02	Tr.	0.18	0.14
33	Spruce, sparse-forest, elevation 3830 m, 28° slope	0—10	54.72	28.82	9.59	2.04	7.15	3.68	1.37	0.04	0.39	0.41
		11—16	31.66	47.55	16.69	3.77	12.68	2.03	1.08	0.04	0.24	0.36
		20—30	11.59	61.17	23.56	4.78	18.54	1.18	1.30	Tr.	0.24	0.19
		55—65	6.88	66.34	24.50	4.78	19.64	0.74	0.99	none	0.07	0.14

Table 4

Total chemical composition of the clay separate (<0.001 mm in diameter) of spruce forest soils, percentages of absolute dry weight

Profile No.	Depth, cm	Loss on ignition	SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	CaO	MgO	MnO	P_2O_5	SO_3
6	8—17	24—29	38.64	33.65	10.55	22.65	0.74	1.20	Traces	0.46	0.38
	24—35	23.19	34.44	38.01	13.65	23.89	0.56	1.28	"	0.46	0.76
	42—48	17.67	33.60	44.06	14.59	28.88	0.47	1.42	"	0.59	0.73
	52—62	25.83	30.98	38.72	14.72	23.23	0.84	1.42	"	0.77	0.70
1	4—9	31.58	34.36	27.00	6.12	20.04	0.52	3.19	none	0.85	0.41
	12—20	15.79	38.54	39.68	8.11	30.76	0.47	3.40	0.07	0.82	0.21
	30—40	15.50	37.06	41.13	12.84	27.68	0.52	3.52	0.04	0.60	0.17
	70—80	10.69	37.37	44.43	12.84	30.98	0.57	4.71	0.09	0.61	0.14
15	21—28	24.56	42.38	29.91	5.99	23.64	1.02	0.67	none	0.27	0.40
	30—35	39.84	18.99	38.37	19.43	18.68	0.85	0.34	Traces	0.25	0.26
	50—60	42.37	20.62	33.47	15.48	17.40	0.65	0.54	"	0.59	0.53
33	0—10	70.80	15.59	9.28	1.88	6.82	1.04	1.48	none	0.58	0.83
	11—16	41.87	30.24	24.46	6.13	17.73	0.95	1.50	Traces	0.60	0.52
	20—30	21.22	38.23	35.11	9.27	25.76	0.66	1.69	0.09	0.08	0.32
	55—65	13.82	41.88	39.86	11.55	28.28	0.75	1.83	0.09	0.02	0.17

larity of SiO_2 accumulation. The separate shows greatest enrichment with Fe_2O_3 and Al_2O_3. Iron compounds are more active than those of aluminum in both the spruce, sparse-forest (Profile 33) and spruce-moss (Profile 15) soils. In the latter and in the soil of Profile 6, as distinct from the others, aluminum is not leached but accumulates in the A_2 horizon. The displacement of Al_2O_3 and Fe_2O_3 in Profiles 6 and 1 soils occurs to a lesser degree.

In the clay separates of all soils with the e ception of Profile 15, there is more MgO tha aO. Calcium and phosphorus are accumulated n the upper horizons. Only in the soils of Proile 1 does the CaO content decrease at a depth f 12-20 cm and the leaching of P_2O_5 is observed n the soil of Profile 15.

This distribution of oxides does not support he development of the podzolization process in oils. Probably, in some soils the accumulaion of SiO_2 does not occur at the expense of the eaching of other oxides.

It is the clay separate's high iron content hich determines its important role in soil tructure formation. This is even more evient from the fact that while there is a compartively large percentage of particles <0.01 and 0.001 mm in diameter in all soils (as revealed y a particle-size analysis, Table 5), the quanity of these particles in micro-aggregate analysis turns out to be two to three times smaller.

Table 5

Particle-size and chemical analysis of spruce forest soils

Profile No.	Depth, cm	Separates, %		Micro-aggregates %	pH of water suspension	Exchangeable cations, meq			Total exchangeable cations, meq	Total exchangeable cations, meq
		<0.001	<0.01	<0.01		Ca	Mg	H		
6	2—5	—	—	—	6.2	—	—	—	—	
	8—17	20.35	55.62	18.33	5.5	11.3	4.5	4.2	20.0	45
	24—35	20.32	44.50	26.42	5.4	4.2	1.4	3.0	8.6	62
	42—48	16.58	39.93	14.17	5.7	3.0	2.2	2.6	7.8	58
	52—62	12.27	29.98	—	5.8	—	—	—	—	78
1	0—2	—	—	—	5.0	—	—	—	—	48
	4—9	—	—	—	5.1	—	—	—	—	80
	12—20	18.30	50.09	17.15	5.4	10.7	4.7	9.2	24.6	64
	30—40	19.69	52.94	32.54	6.2	8.7	4.2	1.8	14.7	36
	50—60	13.85	39.93	23.65	6.3	6.0	2.1	0.5	8.6	19
	70—80	12.22	37.95	—	6.5	—	—	—	—	12
15	0—12	—	—	—	5.6	—	—	—	—	31
	12—20	—	—	—	5.1	—	—	—	—	30
	21—28	22.51	57.53	24.16	4.6	2.7	1.2	13.8	17.7	101
	30—35	14.29	37.30	9.92	4.5	2.6	1.1	4.6	8.3	129
	36—46	6.69	34.12	7.93	5.5	22.8	1.3	4.8	8.9	96
33	0—10	—	—	—	6.2	—	—	—	—	—
	11—16	23.38	48.84	—	5.7	34.0	7.8	4.0	45.8	—
	20—30	23.66	59.28	—	5.6	11.0	3.6	3.6	18.2	—
	40—50	18.32	48.48	—	6.0	11.3	3.4	1.9	16.6	—

The percentage of particles <0.001 mm in iameter is greatest in the upper horizons and ecreases with depth. Even in the soil of Proile 15 at a depth of 21-28 cm, where podzolizaion is morphologically most clearly defined, he percentage of particles <0.001 mm in diameter is considerably greater than in the lower soil layers. It may be that iron is leached from the clay in the form of lower oxides or as humates and fulvates. Moreover only bleaching of the A_2 horizon and not decomposition of its collodial fraction occurs. The high content of iron and the small amount of SiO_2 (soluble by Tamm's method in an oxalate extract; Table 6), as well as the largest amount of available iron (according to Kirsanov's method; Table 5) testify to this.

The fact that the iron content is greatest in the upper horizons is probably associated with the decrease of soil acidity, judging from the pH values (Table 5). These values (Profile 33) increase as we ascend the soil profile. Only in soil under a spruce-moss cover does the pH decrease to 4.5. The content of mobile Al (according to Sokolov's method) in the soils is insignificant (not exceeding 1 meq), and only in the A_2 horizon of Profile 15 does it reach 4.98 meq.

The sum of exchangeable cations (Table 5) in the soils does not exceed 17-24 meq except in the case of spruce sparse-forest soil where

Table 6

SiO_2 and R_2O_3 content soluble in oxalate percentages of absolute dry weight

Profile No.	Depth, cm	SiO_2	Fe_2O_3	Al_2O_3
6	8—17	0.34	1.25	0.91
	24—35	0.28	1.40	1.66
	42—48	0.28	1.61	1.83
1	4—9	0.11	0.66	1.16
	12—20	0.21	1.12	0.56
	30—40	0.35	1.90	1.15
15	21—28	0.18	1.19	2.76
	30—35	0.21	1.84	4.52
	36—46	0.22	1.42	4.05
33	0—10	0.12	0.19	0.80
	11—16	0.26	0.61	1.05
	20—30	0.19	0.73	1.64

it increases to 45 meq. The amount of exchangeable cations in all soils decreases sharply with depth (but it is not less in the horizons where SiO_2 accumulates). Ca^{++} and Mg^{++} are the predominant cations except in horizon A_2 of Profile 15, where exchangeable H^+ is the most abundant. There is no more than 9-37 meq of H^+ in all the remaining soils. Under a spruce-grass mixture association the amount of exchangeable H^+ (in percentages of sum of cations) increases with depth; under all the other soil groups it decreases. This illustrates the variety of processes occurring in them.

The soils of Eastern Tibet are characterized by a large accumulation and unique composition of humus (Table 7). Under spruce-bamboo (Profile 1) and spruce, sparse-forest (Profile 33), there is a greater accumulation of humic than of fulvic acids; their ratio exceeds 1:2 and is more characteristic of chernozem than of podzolic soils. In the soil of Profile 1 fulvic acids are intensively leached down to depths of 30-40 cm, where there is almost four times as much as in the upper layer. Spruce-moss soil, where the ratio of carbon in fulvic acids is reduced from 0.51-0.16, is closer to the moist subtropical forest soils than to north soils.

Soils of fir forests are usually at elevations from 3600-3800 m. Under a fir-moss-and-rhododendron canopy, soils with morphological signs of podzolization are formed. In some of them (Profile 9) there is a distinct A_2 horizon (from 14-22 cm), light-gray in color with a pinkish tinge, under a thick (as much as 14 cm) peaty litter. Below is the B horizon, often of distinctly humus-illuvial nature and reaching a depth of from 63-93 cm; under this a stony-gravelly CD horizon is found. Sometimes the A_2 horizon (Profile 11) is not expressed or is of a spotty character. There ar from 33.9 (Profile 11) to 39.7 (Profile 9) metr tons/ha of litter. This is one-and-one-half to two times more than is found in spruce forests

A total chemical analysis of the soil (Profil 11) at an elevation of 3710 m and a 42° slope (Table 8) reveals an accumulation of SiO_2, a reduction of CaO and P_2O_5 in the A_2 horizon (15-22 cm) and a sharp increase of Fe_2O_3 in the B horizon (30-40 cm). However, analyses of the clay separate indicate accumulation in the A_2 horizon of SiO_2, Al_2O_3 and MgO, leaching of Fe_2O_3 in the B horizon (30-40 cm), and accumulation of CaO in the upper 30 cm layer. Such a distribution of oxides indicate the absence of a podzolization process in these soils

In Table 9 a clay migration and a reduction of micro-aggregation (Profile 9) may be observed in the soils. This is in accord with the more acid reaction of horizon A_2 and with the decrease in exchangeable Ca^{++} and increas in exchangeable H^+. An increased amount of SiO_2 soluble in oxalate extract is observed and a reduction in H^+ and Al except in A_2 and A_1 (5-10 cm) horizons, as may be seen from the following data (Profile 11):

Depth, cm	SiO_2	Fe_2O_3	Al_2O_3
5-10	0.337	0.149	1.075
15-22	0.165	0.574	1.692
30-40	0.187	1.529	1.341

The distribution along the profile of the mo mobile Fe compounds (according to Kirsanov, Table 9) also indicates their migration into th B horizon.

Such a migration of soil minerals is associated with the increased acidity of the humic substances (Table 7), from the increased content of fulvic acids and their migration to lowe horizons. The increase of carbon in the residue demonstrates its stable bonding with soil minerals. In general, leaching processes proceed more intensively under fir than under spruce forests but here, too, the break-down of the colloidal fraction is not noticeable.

Soils of larch sparse forests occur at elevations from 3900-4100 m. They are distinguished by the accumulation of coarse humus litter (up to 7-8 cm in depth), general thinnes and considerable rockiness. They have sufficient humus and exhibit only weak leaching i the lower horizons of Al_2O_3, CaO and MgO (Table 8, Profile 8). The percentage of particles <0.001 and <0.01 mm in diameter is less than in other soils; Ca^{++} is the predominant exchangeable cation, the pH ranges from 5.6-6.3, and the migration of iron is not developed (Table 9).

Thus, with increase in elevation the leachi

Table 7

Humus composition of Eastern Tibet soils, percentages of total carbon content

Profile No.	Depth, cm	Carbon (C)	Extracted by		Humic acids	Fulvic acids	Hydrolyzed N	Residue	C in humic acids / C in fulvic acids
			Alcohol-benzol	Decalcification					
1	0—2	23.07	4.8	0.8	18.7	25.4	3.5	46.8	0.74
	4—9	10.21	4.1	1.3	31.5	23.1	6.0	34.0	1.36
	12—20	5.89	3.7	1.2	41.0	15.4	3.2	35.5	2.64
	30—40	1.86	3.2	3.2	14.0	51.1	5.9	22.6	0.27
15	12—20	42.78	9.7	0.4	12.6	24.5	4.9	47.9	0.51
	21—28	4.40	8.0	1.4	10.4	38.0	5.2	37.0	0.28
	30—35	3.08	2.7	2.3	8.4	54.2	13.6	18.8	0.16
	36—46	3.60	3.0	1.4	9.5	61.6	7.8	16.7	0.15
33	0—10	31.98	6.2	2.6	25.4	16.7	0.6	48.5	1.52
	11—16	12.81	4.4	1.6	22.5	25.4	1.2	44.9	0.88
	20—30	3.64	4.7	1.4	36.0	32.1	1.6	24.2	1.12
	40—50	2.06	6.3	2.0	36.9	19.9	2.4	32.5	1.85
11	0—5	32.36	12.1	2.2	12.7	14.1	3.0	56.0	0.89
	5--10	4.38	9.6	2.3	10.4	28.6	4.1	45.0	0.36
	15—22	2.45	11.8	3.3	10.2	31.0	4.5	39.2	0.33
	30—40	2.18	5.5	2.8	8.7	45.4	6.0	31.6	0.19
8	2—7	42.05	5.8	1.1	11.2	20.1	4.9	56.9	0.55
	7—10	4.43	4.5	1.4	16.5	26.4	4.7	46.5	0.62
	20—30	3.71	3.8	1.9	24.3	32.1	4.0	33.9	0.75
21	0—3	44.10	10.7	22.3	17.1	11.0	0.5	58.4	1.55
	3—12	4.69	4.5	16.4	22.6	14.5	1.7	40.3	1.56
	13—35	1.47	0.7	2.7	23.1	30.6	2.8	40.1	0.76
28	0—10	9.65	3.1	1.6	33.8	19.3	6.1	36.1	1.74
	15—25	5.16	2.3	1.2	40.4	22.3	2.3	31.5	1.81
	30—40	2.31	2.2	1.7	48.5	22.1	3.0	22.5	2.19
	43—51	1.81	3.3	2.3	48.6	20.4	2.8	22.6	2.38

rocesses diminish and saturation increases. Vhether this is due to elevation alone, or hether degree of slope also plays a part, is question requiring further study.

Rhododendron thicket soils of varying kinds re distributed at elevations from 3800-4050 n. As a rule they are excessively moist, ighly clay loam, possess a pseudo-podzolic $_2$ horizon along steep slopes, and are gleyed; neir pH varies from 4.8-5.3 and exchangeable ydrogen comprises 65%-71% of all exchangeble cations. The humus-illuvial horizons are nost prominent.

Let us briefly examine the soils of oak orests. These are found on slopes of south nd southeast exposure at elevations of 3700-600 m. Under virgin oak stands the litter nay be as deep as 3 cm although there is no nore than 26.5 metric tons/ha of it. The finearth layer here attains a thickness of 50-80 m.

At elevations of from 2600-2900 m, where the forests have ordinarily been cut and replaced by secondary growth of scrub oak, the soils have a low humus content and a basic reaction (pH of 8.1-8.3) is due to calcium carbonates.

On slopes of southwest exposure the CO_2 content in the soils is as follows: 3-13 cm, 1.53%; 20-30 cm, 2. 39%; 38-48 cm, 5.21%; 55-65 cm, 3.48%; 75-85 cm, 3.38%. On slopes of northeast exposure, CO_2 appears at a depth of 45-55 cm in the amount of 6.81%; at 65-80 cm, 4.09%; and at 90-100 cm, 4.04%.

$CaCO_3$ is of secondary origin, appearing as the result of internal soil moisture evaporation as a result of the forests being cut. The Paleozoic shales on whose deluvia and elluvia the soils were formed are lime deficient.

At elevations of 3900-3600 m, under a virgin oak canopy, the soils (Profile 21, elevation of 3560 m, 25° slope and southeast exposure) contain no carbonates. They differ sharply from soils under spruce and fir forests

Table 8

Total composition of fir forest, larch sparse forest and mountain meadow soils and their clay (<0.001 mm in diameter) separates, percentages of absolute dry weight

Profile No.	Forest type and site of deposition	Depth, cm	Loss of ignition	SiO_2	P_2O_3	Fe_2O_3	Al_2O_3	CaO	MgO	MnO	P_2O_5	SO_3	Loss of ignition	SiO_2	P_2O_3	Fe_2O_3	Al_2O_3	CaO	MgO	MnO	P_2O_5	SO_3
			Total analysis of soil										Total analysis of clay separate (<0.001 mm in diameter)									
11	Fir-rhododendron, elevation 3710 m, 42° N slope	0—5	61.04	22.74	8.41	1.47	6.68	1.44	0.61	0.05	0.25	0.29	—	—	—	—	—	—	—	—	—	—
		5—15	15.55	60.51	17.66	3.61	13.92	0.62	0.67	Tr.	0.13	0.27	19.01	40.21	30.36	8.33	21.65	0.66	1.13	none	0.37	0.25
		15—22	11.13	65.26	21.92	4.34	17.48	0.53	0.79	"	0.10	0.14	11.22	43.79	33.65	8.28	25.11	0.61	1.53	Tr.	0.27	0.19
		30—40	14.14	57.80	25.37	7.04	18.19	0.65	0.91	none	0.14	0.08	—	35.10	38.69	14.57	23.62	0.48	1.14	"	0.50	0.31
		80—85	6.49	61.06	26.10	5.40	20.61	0.84	1.41	0.03	0.08	0.13	Not determined									
8	Larch sparse-forest, elevation 3920 m, 5° N-E slope	2—7	82.57	10.20	1.75	0.62	0.77	2.26	0.80	0.05	0.36	0.26	—	—	—	—	—	—	—	—	—	—
		7—10	13.43	59.89	24.21	4.76	19.27	0.64	1.18	Tr.	0.18	0.22	—	32.29	33.57	11.35	21.27	0.46	1.84	0.02	0.95	0.37
		20—30	12.59	59.26	24.08	4.75	19.14	0.87	1.03	0.01	0.19	0.13	—	35.52	38.02	11.44	25.58	0.56	2.01	0.04	0.99	0.35
		40—50	5.57	62.06	25.21	4.95	20.10	0.25	1.01	none	0.16	0.09	Not determined									
21	Oak forest, elevation 3560 m S-E exposures 25° slope	0—3	80.36	10.64	4.33	0.76	3.31	2.64	0.49	0.06	0.25	0.23	—	—	—	—	—	—	—	—	—	—
		3—12	14.52	62.84	19.38	7.21	15.03	1.26	0.93	0.02	0.14	0.07	23.83	38.82	31.82	8.96	22.48	0.74	1.27	Tr.	0.38	0.49
		13—35	4.25	68.04	24.46	4.73	19.62	1.17	1.19	Tr.	0.10	0.10	21.52	38.27	36.27	10.11	26.09	0.46	2.28	0.05	0.07	0.35
		58—68	4.43	71.80	20.46	4.22	16.19	0.81	1.18	"	0.05	0.07	Not determined									
28	Short-grass-mixture, "steppe-type" meadow, elevation 3580 m, E exposure, 12° slope	0—10	20.76	51.18	19.06	4.54	14.22	1.78	1.34	0.03	0.30	0.20	38.72	31.11	22.48	6.64	15.82	0.37	1.61	0.04	0.01	0.67
		15—25	14.17	58.56	23.73	4.79	18.67	1.21	1.48	0.02	0.26	0.17	30.58	35.16	30.36	8.25	21.42	0.47	1.83	Tr.	0.69	0.42
		43—51	7.16	67.29	21.93	4.84	16.91	1.86	1.41	Tr.	0.17	0.13	20.65	38.60	35.40	9.07	25.80	0.74	2.14	0.11	0.53	0.94
		53—78	6.94	66.66	23.48	5.36	18.03	0.73	0.87	"	0.10	0.12	—	—	—	—	—	—	—	—	—	—
		88—96	6.19	60.19	28.58	6.75	11.72	0.46	1.02	"	0.11	0.09	8.64	47.53	35.63	7.95	27.58	0.54	1.29	Tr.	0.10	0.22

Table 9

Particle-size composition and certain chemical properties of fir and larch forest and mountain meadow soils

Profile No.	Depth, cm	Particle-size composition, %		Micro-aggregate content, %	pH of water suspension	Exchangeable cation, meq			Total exchange-able cations, meq	Extractable iron, mg/100 g (Kirsanov method)
		<0.001 mm	<0.001 mm	<0.001 mm		Ca	Mg	H		
9[a]	10—12	—	—	—	4.6	Not determined				99
	16—20	19.81	57.61	34.05	4.9	4.6	3.0	8.5	16.1	110
	35—40	23.91	50.23	18.53	5.6	9.0	3.5	7.0	19.5	148
	50—60	22.91	58.28	—	5.9	5.5	2.2	1.9	9.6	133
	70—80	21.67	36.65	—	6.0	Not determined				—
	113—129	—	—	—	6.25	"	"	"	"	107
8	7—10	—	—	—	5.6	26.3	8.3	2.1	36.7	47
	20—30	13.04	36.62	—	6.0	12.7	4.7	0.4	17.8	45
	40—50	9.73	34.11	—	6.3	—	—	—	—	45
21	3—12	22.44	53.57	—	5.9	22.7	3.6	0.7	27.0	19
	13—35	14.55	45.21	—	6.2	5.3	1.9	0.3	7.5	5
	58.60	10.12	41.26	—	6.4	Not determined				3
36[b]	0—6	20.08	49.43	11.66	5.5	12.2	4.4	0.8	17.4	—
	10—20	24.20	54.45	17.91	5.4	7.8	2.6	0.5	11.3	—
	25—35	21.03	50.16	17.86	5.4	5.9	1.6	0.8	8.3	—
	50—60	20.95	47.46	19.78	5.8	3.6	0.9	0.9	5.4	—
	75—85	14.34	39.31	—	5.5	Not determined				—
	100—105	6.66	18.73	—	5.6	"	"	"	"	—
28	0—10	17.32	39.12	6.06	6.4	—	—	—	—	1
	15—25	20.12	45.40	16.24	6.2	22.7	4.3	0.5	27.5	3
	30—40	23.35	46.15	26.99	6.4	13.6	4.3	0.3	18.2	2
	43—51	17.42	41.40	23.83	6.5	10.0	4.9	0.2	15.1	1
	53—58	18.60	47.04	—	6.7	9.4	5.4	0.0	14.8	3
	60—70	9.27	24.36	—	6.7	Not determined				13
	88—96	—	—	—	6.8	"	"	"	"	3

[a] Under fir-rhododendron vegetation, elevation 3625 m, NW exposures, 31° slope.
[b] Alpine meadow, elevation 4800 m, S exposure, 22° slope.

that they possess smaller amounts of Fe_2O_3 nd Al_2O_3 (Table 8), there is almost no migra-on of these compounds in the profile, and ere is more intensive migration of CaO with s evident accumulation in the litter and hori-on A; only MgO increases with depth. Migra-on of the clay particles (Table 9) is not pres-nt. The soils are saturated with Ca^{++}. The $^+$ content is insignificant and their reaction almost neutral (pH of 5.9-6.4). Available on (by the Tamm method) at a depth of 3012 m constitutes 0.963%, at 13-35 cm, 0.119%; l_2O_3 makes up 0.493% and 0.248%, respective-. In the A horizon, accumulation and the larg-st amount of available compounds (according to irsanov) are observed.

Humic acids, the separate extracted by de-lcification, and the carbon in the soil resi-e are predominant components of the humus. The ratio of carbon in humic acids to carbon in fulvic acids in the A horizon is more than 1.5. These facts indicate the special character of the humus, whose action on the minerals of the soil is not intense.

The soils of Alpine meadows, at elevations of from 3900-4100 m and with slopes not exceeding 30°, have a fully developed profile as much as one meter thick.

Here is found a distinctly developed, strongly-sod, cinnamon-brown to brown, powdery, structureless A_0 horizon to a depth of 6-7 cm. The A_1 horizon, which extends to 22 cm, also is cinnamon-brown to brown in color. It is powdery-granular, clay loam. The B horizon is detected to a depth of 74 cm; it has a muddy-brown color, is powdery-granular and gravelly. The CD horizon, extending to a depth of 105 cm, is very gravelly-stony.

Roots may penetrate to a depth of from 70-75 cm. In similar soils from the Tsokusan Pass (elevation 4080 m) particles <0.001 mm in diameter constitute as much as 24% of the A horizon; <0.01 mm, up to 54%; the proportion of the latter particles gradually decreases with depth (Table 9, Profile 9).

The degree of micro-aggregation is high; micro-aggregates of <0.01 mm in diameter are two to four times less numerous than particles of the same diameter as shown by a particle-size analysis. The weakly-acid soils have a pH of 5.4-5.8. The exchangeable hydrogen ion content reaches 1 meq with an exchangeable-cation total of from 17.4 meq in the A horizon down to 5.5 meq in the lower B horizon. Ca^{++} is the predominant exchangeable cation. Thus, unique soils developed on the highest points of the relief are considerably more saturated than those of the Caucasus and other mountain system Alpine meadows.

Soils of the high-mountain plateau. At elevations of from 3400-3700 m in the north so-called steppe section, soils of two types occupy the largest area: 1) peaty-humus soils with lowland peat of from 20 to 70-100 cm in thickness predominate along the most peneplained surfaces (formerly broad valleys with weakly-incised river channels); 2) singular, steppe-type chernozem-like soils are developed along mountain ridges which rise 200-300 m above the valleys; the humus content, which reaches 10% in the A horizon, decreases gradually to 1.8% at a depth of 50 cm (Table 7, Profile 28).

Such soils near the Lonzhiba goskhoz, with a 12° slope and elevation of 3580 m under a short, mixed-grass meadow possess: a sod horizon of as much as 15 cm in thickness, an A horizon extending to 41 cm, an AB horizon to 53 cm and a BC horizon to 80 cm. The fine-clay loam A and AB horizons possess a very well developed granular structure. Beneath there is a rather abrupt transition to gray-cinnamon-brown kaolinized horizons with mottled coloration. At a depth of from 80-90 cm the structure of the shales is preserved, and the horizons are small and kaolinized.

The total analysis of composition (Table 8, Profile 28) confirms the distinctly dual-member nature of these soils. At a depth of 51 cm and lower there is a higher Fe_2O_3 content and a lower content of CaO, MgO and P_2O_5 than in the upper layer. In the latter, according to total analysis of the clay separate, migration of the sesquioxides of Fe, Al, Ca and Mg is clearly expressed.

In the lower layer the Ca content is sharply reduced; as in the other soils, it is less than the Mg content. With soils possessing a high degree of micro-aggregation, the migration of clay particles is noticeable down to a depth of 50 cm (Table 9). Because of saturation of soils by Ca and Mg, the reaction is neutral.

Analysis of the humus (Table 7) shows that these soils differ from alpine meadow soils in possessing a predominance of humic acids. Their specific weight increases with depth while the fulvic acid content remains constant Associated with this fact, the ratio of C in humic acids increases with depth from 1.74-2.38. Of the soils we have examined, this soil possesses the highest such ratio.

Thus, despite the short period with above-freezing temperatures (90 days), intensive humification goes on in the soils which leads to the formation of a chernozem-like profile. Previous warmer and moister soil-forming conditions are indicated by the presence of th kaolinized products of shale weathering.

Among the principal and outstanding features of soil formation at elevations of 3,000-4,000 m in Eastern Tibet are the following:

1) The formation of fully developed soil profiles, despite slopes averaging 40° or more and an increase in thickness with elevation up to the alpine waste lands, 2) The high degree of micro-aggregation along with quite weak, often slight clay migration in the profile.

Morphologically developed podzolization in certain soils is not confirmed by chemical analysis, which indicates an accumulation in the A_2 horizon of Al_2O_3, CaO, MgO and P_2O_5. Th evident leaching is not accompanied by breakdown of the colloidal fraction of the soils.

The increase in SiO_2 content in certain soils on the lower portions of slopes may be associated with its precipitation in the form o chalcedony or opal from water entering from the Alpine zone; there the solubility of SiO_2 is probably great. The predominance of Mg over Ca in the clay fractions demonstrates th "magnesium" character of the soil province: the present soil-forming parent material has had its effect on the processes of soil formation.

The richness of the soils in iron and alum um is due to the weathering intensity of pare material and the continually increasing effec of the transportable products of organic deca matter which accumulates under the forest canopies. Therefore, the soils differ significantly in humus composition from those fami iar in the literature; the high ratio of C in humic acids to that of fulvic acids emphasize this fact.

All soils possess such unique characteris at it is difficult to relate them to soil groups own to us from other mountainous countries. evertheless, at the present stage of investiga- ons it is more to the point to draw analogies tween them and already-studied soils, while nphasizing their provincial differences. These e due to a high-mountain environment over- id with both subtropical and moderately cold oclimatic zones.

We have isolated the following groups and bgroups of soils:

1) Cinnamon-brown earths: under oak rests, consisting of: a) cinnamon-brown, condary-calcareous soils leached in varying grees at elevations of 2600-2900 m on slopes south, southeast and southwest exposure; b) own-cinnamon-brown non-calcareous soils slopes of the same exposure at elevations from 2900-3600 m (Profile 21).

2) Brown earths: under coniferous-broad- aved and spruce forests, consisting of: a) rk-brown soils at elevations of from 2600- 00m; b) brown soils on south and southeast slopes at elevations of from 3000 to 2500-3600 m; and c) brown, peaty, leached soils along the north and west slopes at elevations of 3300-3700 m.

3) Pseudo-brown-podzolic: under fir and fir-spruce forests at elevations of from 3600-3800 m on slopes of north and west exposures with subgroups: a) pseudo-brown-podzolized (Profiles 11 and 9); b) peaty-gleyed, pseudo-podzolic and pseudo-podzols (Profile 15).

4) Alpine meadow-forest soils: under spruce and larch sparse forests at elevations of from 3800-4100 m.

5) Alpine chernozem-like-mountain-meadow ("steppe-like") soils at elevations of from 3500-3800 m.

6) Alpine peaty-humus-gleyed and low-moor soils at elevations of from 3300-3500 m.

7) Alpine mountain-meadow soils at elevations of from 3800-4100 m.

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AGRICULTURAL SOIL DISTRICTS AND RELATIVE EVALUATION OF SOILS[1]

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The division of the administrative oblasts and krays into agricultural soil districts has been practiced for a long time. However, the resulting data have been used very little by planning and operational organizations because these results are still too general. Neither an adequate consideration of the productive capacity of the soils nor an economic evaluation of the lands has been achieved. Excessive detail about individual soil boundaries and insufficient knowledge of how to combine them into management groups on the basis of similarity in fertility level and improvement methods have also hindered the use of cartographic and explanatory materials by local workers.

In order to transform the data of agricultural soil districts into a really scientific basis for solving practical problems such as planning, allocation, specialization and organization of agricultural production, they must be made thoroughly specific. One of the ways to accomplish this is to calculate as fully as possible the production characteristics of soils, including a quantitative evaluation of their fertility.[2] Then the agricultural soil districts will be specific units defined on the basis of both natural conditions and production indices.[3]

When dividing Gor'kovskaya Oblast' into agricultural districts (in 1956), we tried to work out a scale of relative soil evaluation which would have basic agricultural management value.[4] The first results of this effort are reported in this article.

By relative evaluation we mean the numer cal relationships between soil fertility levels for a farming system. Fertility, of course, is the most important agronomic property of soils, determining their productive value. Soil fertility indices accepted by both scientis and farmers are: the humus content, thickne structure, P_2O_5 content, etc. of the plow laye Combined use of the foregoing and other indic will produce a more or less correct description of this most important of soil properties However, a much more objective and desirable quantitative index of the soil fertility lev is systematically obtaining crop yield. It is therefore obvious that an evaluation of soils (classification by site index) from crop productivity data is both possible and expedient the present time.

When large-scale soil maps are available the relative evaluation of soils in each indivi al farm may be conducted under production conditions by computing the yields on special small plots or on large sections. The latter of course will be more accurate. A series c procedural difficulties arise when evaluating the soils of large areas: possible climatic differences and non-homogeneity in the level of agricultural practices on the farms must taken into account.

An analysis of meteorological data indicat that there were no differences in climate bet the various districts of Gor'kovskaya Oblast' significant enough to introduce correction co efficients into soil fertility calculations. Th effect of cultivation intensity on soil fertility is more complicated. Preliminary processi of statistical materials on relative productiv a taken over many years with the same agri- tural practices distinctly exhibit the signifi- ce of the natural features of comparable ls through difference in fertility level (i. e. differential yield I, which is based on soil lity).

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[1] Presented at the First Delegate Session of Soil Scientists, May 1958.

[2] The first attempts to evaluate lands which are now a part of Gor'kovskaya Oblast' are to be found in 16th and 17th century cadasters; in 1838-1867 the Ministry of State Properties evaluated the lands. Dokuchayev (7) and Sibirtsev (3) made the first scientific evaluation of land.

[3] By agricultural soil district we mean a natural management unit which possesses a uniform climate, approximately uniform levels of soil fertility, and consequently the same farming system (i. e. production measures which guarantee rational agricultural usage of the land and improvement of soil fertility).

[4] All the data of this report relate to the Gor'kov skaya Oblast', 1956.

Our method for obtaining the relative evalua- 1 of soils (as points on a scale) consists of two ps: 1) Computation of relative yield indices; Computation of soil evaluation numbers.

It would have been most expedient to use ld data from State experimental plots in 'eloping a relative soil evaluation scale. wever, they by no means contain all the st important agricultural soils in Gor'kov- iya Oblast. Furthermore, the level of agri- tural practices is considerably higher there n on most kolkhozes. Therefore, it is te evident that yield data from State experi- ntal plots would not, at the present time, lect the soil fertility of much of the Oblast's 'icultural land.[5] However, taken in conjunc- n with kolkhoz and sovkhoz yields (with differ- levels of agricultural practices), these data ıld provide a measure of effective soil fer- ty (i. e. differential yield II, which is based production outlays).

In order to relate the level of the yields to ural soil features, statistical materials m particular kolkhozes were used — those h similar and also average levels of technol- y[6] — thus describing the fertility of the pre- nderant part of cultivated soils.

The cultivated soils of Gor'kovskaya Oblast' d-podzolic and light-gray forest soils) differ le in the thickness, humus content, and ucture of the plowed layer or in certain er indices (Table 1). The basic determin- s of fertility differences are: texture (in rticular, rock content), nature of underlying 'ent material, and physicochemical proper- s (pH, degree of base saturation, etc.).

Guided by soil maps (regional, Machine and actor Station and kolkhoz), we designated tions of the Oblast' and kolkhozes within se sections possessing the most typical ls. A total of 98 kolkhozes (187,000 ha of wed land) were selected, which were then ided according to soil characteristics into groups. Yearly kolkhoz records taken r three years (1953-1956) furnished the necessary information. This included data on yields of winter rye, all grain crops,[7] hay crops, potatoes, and flax as well as amounts of fertilizer (organic and mineral) applied per hectare of plowed land.

Relative productivity indices were computed in the following manner. The original statistical data on productivity were processed separately according to year, crop and soil. As a result, the average yields per hectare for all crops were calculated by years and soils. Furthermore, the sums of the three-year average yields were determined for each crop. From these were obtained many-year average yields, which were adopted as representative units of the scale of relative productivity indices. Specific yields were expressed as fractions of the representative units.

Thus the fertility of each soil for each year was described by certain relative productivity indices (according to the number of crops considered). When subsequently calculating the soil evaluation numbers, only the indices for winter rye and "all grains" were used. It seemed necessary at this first stage in the work to choose the most essential objective indices of soil value; for Gor'kovskaya Oblast' soils this index turned out to be the yield of grain crops (occupying 60%-70% of cultivated lands in the various districts).

It is evident from the data of Table 2 that relative productivity indices in all cases deviate only slightly from the mean. Such uniformity cannot be accidental. It indicates that, given the same agricultural practice, grain yields obtained on various soils under varying meteorological conditions[8] remain approximately equal. Consequently they reflect differences in levels of soil fertility and may be taken as indices of their agricultural value.

The relative productivity indices of other crops, in conjunction with those for grains, point out those soils best suited for certain plants, as well as for the most commercially promising crops for individual kolkhozes and soil management districts. Thus, for example, the most favorable soil for potatoes was coarse-clay loam;[9] for flax, medium-clay loam; for clover, sandy-loam shallowly underlaid (0.8-

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The author's contention that productivity data n State plots do not reflect the soil fertility re- s only to the non-chernozem zone—Editor.

The very great differences between kolkhozes of ering agricultural levels lead to non-uniform ication of fertilizers (organic and mineral) and iable cropping systems.

[7] In kolkhoz records, the heading "all grains" includes winter and spring legume bean crops.

[8] 1953 was favorable for winter and spring crops; 1954 had a hot summer and not enough precipitation; 1955 was not warm enough during the summer and was quite wet.

[9] Ladygin (2) established the same result in his work.

Table 1

Variation limits of certain properties of arable soils in Gor'kovskaya Oblast'

Soils	Humus, %	Depth, cm	Available P_2O_5 per 100 g of soil (Kirsanov method)
Sod-medium-podzolic, fine and medium silty-clay loams on clay loams and clays	1.1—3.0	16—20	2.5—18
Sod-medium-podzolic, sandy loam soils on ancient alluvial sands	0.8—2.6	16—20	2.5—13
Light-gray forest, strongly podzolized, coarse silty-clay loams on loess-like clay loams and clays	1.3—3.2	16—22	2.5—20

1.0 m) by original (Permian) clays, marls or sandstones.

Evaluation scales of soil calculated from relative productivity data on winter rye and "all grains" are presented in Table 3. They were computed in the following manner. The highest relative productivity index means were taken as unity in the soil evaluation scale. All other indices of relative productivity were expressed as fractions of unity. As may be seen from Table 3, the evaluation numbers are quite close together. The numbers for "all grains" are somewhat higher, but mean deviations in no case exceed ±0.06. It would seem that for practical usage any scale might be adopted. In our opinion, a scale calculated on the basis of the rye yields is preferable. The agricultural practices are fully utilized in the management of this crop. Thus the yields of winter rye better demonstrate the effect of the natural soil features and are a more reliable evaluation criterion.

Turning now to the evaluation numbers, it must be observed that the Oblast' soils differ considerably in levels of relative productivity. The fertility of the best soils is four to five times greater than that of the poorest. This suggests the agricultural possibilities for kolkhozes with non-homogeneous soils, and also serves as a warning against using the same management techniques. Using the site index numbers, it is possible to group the soils objectively according to fertility level and to evaluate management areas (individual fields, kolkhozes, districts, etc.).

Our method of evaluating soil fertility is thus based upon objective initial data. Soil fertility is expressed in terms of relative indices of grain crop productivity. It shoul be emphasized again that a direct comparison of soil fertility on the basis of yields is possible only when the agricultural practices and farming systems are the same. As cultivation is intensified, soil fertility is modified and the total yield increases. Although this does not alter the site index numbers appreciably (data from the last column of Table 3 illustrate the general narrowing of the difference between poorer and better soils), elements entering into the index numbers do change. Correction coefficients relating to the degree of cultivation of the soils must be introduced; according to preliminary calculations thes may be as great as ±0.2-0.3 (added to the mean level). Correction coefficients must also reflect the effect on soil fertility of the degree of podzolization, wat logging, erosion and other factors. Calc lation of these coefficients is the next st and indeed some work has already been done in that direction. It has been show that the fertility of light-gray forest soil is depressed by as much as 0.15 on the index when there is slight erosion, by 0.35 with moderate erosion, and by 0.55 with severe erosion. The effect of podzoliz tion does not exceed 0.18. At the present ti the soil evaluation numbers for the Oblast' have only general orientation value; they can be made the basis of certain economic ca culations.

Considerable damage to the agricultur economy results from disregarding qualit tive soil evaluation. An incorrect appro to production specialization on the part individual kolkhozes and districts is fost

Table 2

Relative productivity indices of grain crops for various Gor'kovskaya Oblast' soils

Soils	Years	Winter rye		"All grains"	
		Productivity index	Average over 3 years	Productivity index	Average over 3 years
Sod-medium-podzolic, fine and medium silty-clay loams on clay loams and clays	1953 1954 1955	1.14 1.16 1.23	1.18	1.20 1.07 1.11	1.13
Sod-medium-podzolic, coarse silty coarse clay loams on clay loams and clays	1953 1954 1955	1.16 1.27 1.22	1.22	1.20 1.12 1.25	1.19
Sod-medium-podzolic, coarse-clay loams on clay loams with underlying sands	1953 1954 1955	0.88 0.78 0.78	0.79	0.89 0.85 0.78	0.84
Sod-strongly-podzolic clay loams on thin morainic clay loams with underlying sands	1953 1954 1955	0.68 0.64 0.72	0.68	0.74 0.69 0.69	0.70
Sod-weakly-podzolic sandy loams on original sandstones	1953 1954 1955	0.90 0.83 0.94	0.89	0.96 0.92 0.99	0.95
Sod-medium-podzolic sandy loams on ancient alluvial sands	1953 1954 1955	0.58 0.57 0.60	0.58	0.62 0.64 0.55	0.60
Sod-medium-podzolic sandy loams on detrital glacial sands	1953 1954 1955	0.49 0.48 0.56	0.51	0.56 0.52 0.56	0.53
Sod-weakly-podzolic sands on deep glacial sands	1953 1954 1955	0.31 0.33 0.29	0.31	0.34 0.36 0.32	0.33
Light-gray forest, strongly podzolized, coarse silty-clay loams on loess-like clay loams and clays	1953 1954 1955	1.42 1.37 1.43	1.41	1.35 1.48 1.44	1.42
Light-gray forest, medium silty-clay loams on loess-like clay loams and clays	1953 1954 1955	1.59 1.66 1.68	1.64	1.55 1.46 1.54	1.52

ecommendations for crop rotation or gronomic procedures are pushed through vithout consideration of soil characteristics or the earning capacity of lands occurring under different natural conditions.

In the light of these remarks, the value f relative soil evaluation is obvious. Agronmists and agricultural practitioners may ompare and group soils objectively on he basis of their productivity, which is ery important for setting production goals. hey can also discover the most favorable soils for different crops and evaluate farmland quantitatively (on the basis of agricultural soil districts). Thorough consideration of the natural conditions of specific areas is acquiring great usage as a means to increase agricultural productivity. The division of land into agricultural soil districts, with detailed and thorough analysis of the natural conditions (especially the basic agricultural resources, soil and climate), is a practical application of this approach.

The primary requirement for agricultural

Table 3

Relative evaluation numbers of Gor'kovskaya Oblast' soils

Soils	Years	For winter rye: By year	For winter rye: Aver. over 3 yrs.	For "all grains": By year	For "all grains": Average over 3 years	Mean eval. no. for soils of best farms (winter rye)
Sod-medium-podzolic, fine and medium silty-clay loams on clay loams and clays	1953 1954 1955	0.71 0.70 0.73	0.71	0.77 0.73 0.72	0.74	0.73
Sod-medium-podzolic, coarse silty-clay loams on clay loams and clays	1953 1954 1955	0.73 0.76 0.73	0.74	0.77 0.80 0.81	0.79	0.77
Sod-medium-podzolic, coarse-clay loams on clay loams with underlying sands	1953 1954 1955	0.54 0.48 0.47	0.50	0.57 0.58 0.58	0.55	0.54
Sod-strongly-podzolic clay loams on thin morainic clay loams with underlying sands	1953 1954 1955	0.44 0.39 0.43	0.42	0.48 0.47 0.44	0.46	0.94
Sod-weakly-podzolic sandy loams on original sandstones	1953 1954 1955	0.58 0.51 0.56	0.55	0.62 0.63 0.63	0.63	0.50
Sod-medium-podzolic sandy loams on ancient alluvial sands	1953 1954 1955	0.36 0.34 0.36	0.35	0.40 0.42 0.35	0.39	0.38
Sod-medium-podzolic sandy loams on detrital glacial sands	1953 1954 1955	0.31 0.29 0.35	0.31	0.36 0.35 0.36	0.36	0.35
Sod-weakly-podzolic sands on deep glacial sands	1953 1954 1955	0.19 0.21 0.18	0.19	0.22 0.24 0.21	0.22	0.28
Light-gray forest, strongly podzolized, coarse silty-clay loams on loess-like clay loams and clays	1953 1954 1955	0.90 0.83 0.85	0.86	0.89 1.00 0.93	0.94	0.88
Light-gray forest, medium silty-clay loams on loess-like clay loams and clays	1953 1954 1955	1.00 1.00 1.00	1.00	1.00 1.00 1.00	1.00	1.00

soil districts is, therefore, the rapid development of a relative evaluation method applicable to all agricultural soils (field, meadow, and pasture land). To this end, close cooperation of soil scientists, agronomists and economist-managers is absolutely necessary.

The relative soil evaluation will not only serve the purposes of agricultural soil districts but will also aid production organization of kolkhozes and sovkhozes.

The V. V. Dokuchayev Soil Institute (Academy of Sciences, USSR) must, with the help of other organizations, develop a method to solve the complex current problem of relative soil evaluation. Soil science departments and agricultural institutes, as well as departments of economics and agricultural production organization, mus work out soil evaluation scales for local environmental management condition There is no doubt that in the long ru this great collective work will lead to the creation of a single evaluation scal for soils of all parts of this country.

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A SCHEME FOR THE QUALITATIVE EVALUATION OF LANDS OF THE LATVIAN SSR[1]

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Achievements of agricultural production are usually described in terms of production per 100 hectares of usable land. We know that an increase in production, production quality and cost depends upon a number of factors among which the natural conditions of the area and the cultivated state of agricultural lands are of great importance. In comparing the production indicators for different farms and for workers' crews of separate farms, we must consider the quality of land.

A so-called cadastral census used to estimate taxes has already been in use for a long time in several foreign countries. The cadastral census based on a qualitative evaluation of land has its own history in Latvia. The first efforts in this direction were begun during Swedish occupation and lasted from 1688 through 1693. The Swedish cadaster fixed the earning capacity of land depending upon the quality of soil. Four site quality classes were set up in the Swedish cadaster.

Class I — black plowed soil 60 cm thick (24 inches) with a clay subsoil.

Class II — black-cinnamon brown or dark-gray soil 30 cm thick (12 inches) with a clay subsoil.

Class III — light-cinnamon brown soil mixed with sand, 12.5-17.5 cm (5-7 inches) thick with a yellow sandy subsoil.

Class IV — light-cinnamon brown or gray soil 7.5-12.5 cm (3-5 inches) thick with a mellow moist subsoil.

Peasant land was subdivided into three groups or classifications of land based on how these lands were used: 1) grain-producing land with a three-field crop rotation, where manure was added to each field every third year; 2) unuse forest land (20-25 years after cutting); and 3) used forest land.

The value of the lands was determined in taxonomic units, talers and groschen, according to use and quality. If we express the value of the best lands (first-class grain-producing land) as 100%, the value of the most inferior land (fourth-class used forest land) will be 12.5%.

We might mention also work in general land surveying and land taxation at the beginning of the Nineteenth Century and land evaluation in the Liflyandskaya Guberniya at the beginning of the Twentieth Century. These projects, compared with the Swedish cadaster, did not come forth with any essentially new land evaluation methods.

A more thorough study of soils and a cadastral evaluation of lands was begun in Latvia in 1931. Ya. Vityn'sh headed the soil research work for the cadaster. To work out instructions for a cadastral census, preliminary studi of soils on farms in different countries were made and economic data was collected and proc essed. The value of the soils was expressed i points or percent, taking for 100 points the productive capacity of one hectare of the best plowed soil, which yields the highest return from ordinary agricultural methods. The plowed soil is subdivided according to natural conditions (by soil properties, water regime, etc.), into 9 site quality classes; the meadows into 8, the natural pastures into 5, and the for soils into 5.

The cadastral evaluation was conducted in 6 counties (out of 18), but only from three countries was the data completely processed and pu lished. The Second World War interrupted the activities and they were not continued afterwar

In 1957 soil scientists of the Latvian Scientific Research Agricultural Institute and the Latvian Ministry of Agriculture began a new draft for the qualitative evaluation of soils of the kolkhozes and sovkhozes of the Republic. K. K. Brivkaln and soil scientists K. Tsirulis and Ya. Kaurat headed the work.

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[1] Reported at the First Delegates' Session of Soil Scientists, May 1958.

In devising the present scheme we used the most recent soil-cartographic data and production indicators of the kolkhozes and other farms, and also availed ourselves of the experience obtained from the former cadastral evaluation of Latvian lands. Moreover, we made additional studies of soils and conducted a preliminary evaluation of lands in the kolkhozes.

In developing a point system of soil evaluation it was difficult to define correctly the importance of the individual properties and conditions that determine the productive capacity of the soil.

These conditions may be classified as follows:

I

Fixed conditions or conditions presently difficult to change

1. Climate
2. Relief (macro- and mesorelief
3. Soil-forming parent material and soil texture
4. Size of the cultivated areas (contours) in hilly regions

II

Conditions that can be changed by improvement measures

1. Moisture (in the Republic mostly excessive)
2. Microrelief of the soil and stoniness
3. Structure of low-lying horizons (A_2 and B)

III

Conditions that can be changed by agricultural technology

1. Soil reaction
2. Depth, porosity and structure of the plowed layer
3. Humus and nutrient content and content of substances harmful to plants
4. Macro- and microfauna of the soil

The Central Vidzemskaya and Aluksnenskaya elevations are characterized by comparatively unfavorable climatic conditions (much precipitation, less heat and a short growing period). There is less heat also in the remaining northeast part of the Republic.

Therefore, the productive capacity of plowed soils here must be rated lower than those in the rest of the Republic. Drained plains and slopes where relief and moisture conditions are more favorable for agricultural production should be rated higher than depressions that are difficult to drain, and sloping and steep slopes of hills. Expressed microrelief and stoniness also lowers the value of land.

Texture and quality of the soil-forming parent material have a considerable effect on the productive capacity of the genetic soil species. Soils with a clay loam and sandy loam texture are the best mineral soils of the Republic, while soils with a sandy, gravel, and very fine texture are the worst. Important also is the presence of carbonates.

The best soil-forming parent materials are the carbonate moraine and boulderless clay loam, coarse and medium boulderless silty clay (of limnoglacial and alluvial origin). We should rate somewhat lower the two-layer deposits that promote water logging — the clay loams on clay, the sandy loams and sands on clay loams or on clay. The maritime sands, the slightly-friable compacted parent materials (dolomites, limestone, sandstone, compacted boulderless clay) and peat deposits of upland bogs belong in the category of least valuable soil-forming parent materials.

In addition, we must add as principal features characterizing the fertility and value of soils and extent of their cultivation: thickness of humus horizon, quantity and character of humus (organic matter), structure, reaction, porosity and compaction of horizons, podzolization and gleying signs, as well as signs characterizing plant root growth and activity of soil fauna (earthworms).

Quality of lands should be determined in their present state. This will enable us to control the change in land quality after several years, by re-evaluation.

Based on the foregoing considerations, we have constructed an evaluation table for plowed lands. As in the former cadastral evaluation we have adopted the 100 point system (Table 1).

The table is divided across into ten columns. In the first column are the land groups and the number of points in a scale for each group. In the second column are the land classes and the number of points in each class. The third column indicates the characteristics of the conditions in the area (relief, extent of moisture,

Table 1

Evaluation of plowed lands-plowed fields, gardens, orchards and perennial grasses distributed on the plowed field.

Groups and No. of points on scale	Classes and No. of points on scale	Relief, moisture conditions, extent of cultivation, stoniness, etc.	Soil characteristics	Soil groups, subgroups, and species	Qualitative evaluation of 1 hectare of land considering soil texture and soil-forming parent materials (0-1m)									
					Friable, coarse and medium clay loam, rich in carbonates		Friable and medium compacted clay loam and clay, and sandy loam underlain by cl. lm. or cl.		Cohesive and silty sand underlain by clay loam or clay		Sandy loam, clay gravel, cohesive and silty sand (also stratified)		Gravel, sand compacted clay (also stratified)	
1	2	3	4	5	6		7		8		9		10	
					a^1	b^1	a	b	a	b	a	b	a	b
1. 100-81	I 100-91	Drained plains and slopes. Moisture conditions and cultivation very good. Areas suitable for mechanization	Best soils. Soils with a thick A_1 horizon (>30 cm) with high content of humus (>3%) good structure and texture. Signs of podzolization and gleying missing; pH ≥6.0	1. Sod-carbonate typical and leached. Soils of granular bottom land. Cultivated soils^a	100	94	96	91	—	—	—	—	—	—
	II 90-81	Same. Areas of average size	Soils with less humus or with weak signs of gleying	Same	90	85	87	83	83	81	—	—	—	—
2. 80-61	III 80-71	Plains and slopes. Moisture conditions generally good. Cultivation good. Areas suitable for mechanization. Thickness of friable layer of soil above compacted and bouldered parent materials >60 cm	Good soils. Soils with thick A_1 horizon (>25 cm) average amount of humus (≥2.5%) and good structure and texture. May have weak signs of podzolization and gleying. Soils with fine texture, during years of abundant precipitation excessively moist. Soil reaction near neutral (pH >6.0)	1. Sod-carbonate soils of granular bottom land and cultivated soils	80	75	77	73	73	71	—	—	—	—
				2. Sod-weakly podzolic, medium cultivated	75	71	—	—	—	—	—	—	—	—

Table 1 continued

2. 80–61	IV 70–61	Same. Areas of average size. Strips broken up by open ditches, with soils of Class III	Soils with average structure and texture. Soil reaction may be slightly acid (pH >5.5)	1. Same 2. Same and alluvial soils (thickness of A_1 horizon >30 cm)	70	66	67	64	65	61	—	—	—	—
3. 60–41	V 60–51	Plains and inclining slopes (angle of slope to 10^0). Moisture conditions satisfactory. Areas cultivated suitable for mechanization. No soil erosion or else slightly eroded. Thickness of friable layer of soil above compact and bouldered parent materials >50 cm	Average quality soils. Soils with medium thick A_1 horizon (>20 cm). Average content of humus (about 2%), may have signs of podzolization and gleying. Soils of fine texture and stratified materials often requiring additional drainage. Sandy loam soils with a thick A_1 horizon (>25 cm); pH ⩾5.5	1. Sod-carbonate, soils of granular and transitional bottom lands, and cultivated soils	60	57	58	55	56	53	54	51	—	—
				2. Sod-weakly podzolic and alluvial soils (thickness of A_1 horizon >25 cm)	58	55	56	53	54	51	54	51	—	—
				3. Sod-medium podzolic and sod-gley soils well cultivated	56	53	55	52	53	51	53	51	—	—
3. 60–41	VI 50–41	Same. Thickness of friable layer above compact and boulder rocks less (30–50 cm). Soil erosion on slopes slight, in places, average. Stoniness negligible	Soils with more expressed signs of podzolization or gleying more compact texture or more acid reaction; pH ⩾5.2	1. Same and soils of stratified bottom land and sod-gley soils	50	47	48	45	46	43	44	41	—	—
				2. Same	48	45	46	43	44	41	44	41	—	—
				3. Same and sod-podzolic-gley and humic-gley lowland bog (well cultivated)	47	44	46	43	45	42	44	41	—	—

Table 1 continued

Groups and No. of points on scale	Classes and No. of points on scale	Relief, moisture conditions, extent of cultivation, stoniness, etc.	Soil characteristics	Soil groups, subgroups, and species	Qualitative evaluation of 1 hectare of land considering soil texture and soil-forming parent materials (0-1 m)									
					Friable, coarse and medium clay loam, rich in carbonates		Friable and medium compacted clay loam and clay, and sandy loam underlain by cl. lm. or cl.		Cohesive and silty sand underlain by clay loam or clay		Sandy loam, clay gravel, cohesive and silty sand (also stratified)		Gravel, sand compacted clay (also stratified)	
1	2	3	4	5	6		7		8		9		10	
4. 40–21	VII 40–31	Plains, depressions and slopes (angle of slope up to 15°). Moisture conditions partly regulated. Moisture may be periodically deficient or excessive. Partly cultivated area and wastelands. Areas of individual contours average. Erosion on slopes slightly expressed or average. Thickness of friable layer above compact and boulder materials >30 cm	Soils below average quality. Partly cultivated soils, thickness of A_1 horizon > 15 cm, low content of humus (1%–2%). Soils with coarse texture deeply podzolized. B horizon of clay soils compacted. Reaction of podzolic soils acid; pH >4.5. Sod-carbonate and bottom land soils, usually contain little humus, often skeletal soils. Sod-podzolic-gley soils without iron concretions in horizon. Soils of lowland and transitional bogs medium cultivated. Sandy soils with thick A_1 horizon (⩾25 cm), and humus content >2%	1. Sod-carbonate soils of transitional and stratified bottom land, sod-weakly podzolic (eroded), sod-gley and alluvial soils.	—	—	40	37	38	35	36	33	34	31
				2. Sod-medium podzolic (and eroded), and sod-podzolic gley soils.	40	36	38	35	36	33	34	31	—	—
				3. Humic-peat-lowland (cultivated).	40	36	40	36	40	36	40	36	40	36
				4. Humic-peat gley transitional (cultivated)	—	—	35	33	34	32	34	32	33	31
4. 40–21	VIII 30–21	Same. Erosion and stoniness average, severe in spots	Same. Weakly cultivated soils, sandy soils of average humus (1%–2%)	1. Same	—	—	30	28	28	26	26	24	24	22
				2. Same and sod. Strongly podzolic	30	28	28	26	26	24	24	22	22	21
				3. Same	30	26	30	26	30	26	30	26	30	26
				4. Same	—	—	26	22	26	22	26	22	24	22

Table 1 continued

5. 20– 5	IX 20–11	Sandy plains, depressions and slopes (angle of slope up to 20°). Moisture conditions not regulated. Moisture usually in excess or deficient. Waste lands and partly cultivated plots. Areas of individual contours may be small (<1 ha). Erosion on slopes expressed as average or severe. Boulder areas. Thickness of friable layer above compact and boulder materials (layers) ⩾20 cm	Low fertile and hard to cultivate soils. Partly and weakly cultivated soils with poor physical and chemical properties. Water-logged soils with compacted illuvial-humus and iron concretion in horizon. Bog soils with medium and weakly decomposed peat. Sod-carbonate and flood plain soils dry, contain little humus. A_1 horizon small	1. Sod-carbonate (skeletal) sod-medium and strongly podzolic, soils of stratified bottom land and sod-podzolic gley soils	—	—	—	—	20	18	18	16	12	11
				2. Typical podzolic, partially developed, peat-gley-bog	—	—	—	—	14	12	12	11	12	11
				3. Peat soils of transitional bogs	—	—	20	18	20	18	20	18	20	18
	X 10–5	Same. Thickness of friable layer above compact and severely rocky layers < 20 cm	Primitive, severely skeletal and soils of top bogs, (partly cultivated)	1. Same	—	—	—	—	—	—	10	9	9	8
				2. Same	—	—	—	—	—	—	—	—	6	5
				3. Soils of top bogs	—	—	—	—	10	8	10	8	10	8

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[a] By cultivated soils we mean those that are normal under the given conditions where cultivation methods are employed (drainage, rock removal, liming, fertilization, etc).

Explanation: 1. Points in column "a" are for districts of the Republic with more favorable climatic conditions. Points in column "b" are for districts with less favorable conditions (districts: Limbazhskiy, Ruyenskiy, Valmiyerskiy, Valkskiy, Tsesisskiy, Smiltenskiy, Ergl'skiy, Madonskiy, Gulbenskiy, Aluksnenskiy, Balvskiy, and Karsavskiy) and for those places in the Republic where we more frequently find early fall and late spring frosts: 2. The pH valve is given in salt solution.

adaptability to machinery, stoniness, cultivation, thickness of friable layer on strongly bouldered and compacted materials and extent of erosion). These conditions deteriorate as we go down the page. The first four classes represent chiefly conditions of the Zemgal'skiy soil district, where flat and sloping to undulating relief is predominant. The chief factors that lower the land value here are temporary excess moisture and a parcellation (to some extent) of the area by open ditches. These factors can be eliminated by introducing closed drainage. Classes V and VI correspond by area conditions, for the most part, to the Kurzemskiy, Srednelatviyskiy, Severovidzemskiy and partly to the Vostochnolatviyskiy (Lubanskiy) soil districts having a sloping to undulating and undulating relief of the main moraine. Here the plowed land areas are distributed on inclining slopes (up to 10° angle) and on elevated plains. Moisture conditions during years of normal precipitation are generally satisfactory, but in wet years we see an excess of moisture. Erosion is slight on slopes; stones have been removed from fields or stoniness is negligible.

The area conditions for Classes VII and VIII are typical of the Vidzemskiy and Vostochnolatviyskiy soil districts, and for sections of other soil districts having a terminal-moraine hilly relief. The plowed fields are distributed almost entirely on the slopes of hills (angle of slopes up to 15°). Moisture conditions for field crops differ; moisture may be periodically excessive or deficient. The contours of cultivated areas are average and small. Water erosion is widespread and conditions for mechanizing field work are more unfavorable (relief, stones) than found on flat and undulating relief. The plowed lands on sandy plains, especially of the Primorskiy soil district, and in inadequately drained depressions also come under these classes.

Classes IX and X belong by area conditions in the category of slightly cultivated or hard-to-cultivate plots within different soil districts.

The fourth column of Table 1 shows the characteristics of the principal diagnostic features of soils according to groups and classes. In the first group are indicated characteristics of the best plowed soils of the Republic; in the second, characteristics of good soils; in the third, those of average soils; in the fourth, those of soils below average quality; and in the fifth group, characteristics of low productive, difficultly cultivatable soils. Susceptibility to cultivation generally decreases as we go from the first to the fifth group.

As we can see from the table, each group is divided into two classes. Indicators corresponding to the best soils of this group characterize the first class. Soils with several inferior qualitative characteristics belong in Class II.

Column 5 of the table gives the genetic groups, subgroups and species of soils according to site quality classes.

Columns 6-10 represent a relative evaluation of one hectare of plowed land expressed in points (or percent) on a scale. They are differentiated in greater detail in each class depending upon texture and soil-forming parent materials. In each column (6-10) there are two letters ("a" and "b"); the first letter represents conditions in the southern and western part of the Republic with more favorable climatic conditions; and the second letter represents conditions in the northeast part of the Republic where climatic conditions are less favorable.

Soil species were grouped by classes based on their relative productivity under average levels of agricultural technology.

This evaluation table of plowed lands is only a basic table for constructing more suitable small working tables with corresponding abbreviations using letter designations for soils, numerical data for texture, etc.

In constructing an evaluation table for meadows and natural pastures we were guided by the following considerations:

1) In evaluating meadows and natural pastures on lands outside the plowed field we should first consider the value of the soils and the extent of cultivation of a given area.

The concept of cultivation means that we have used cultivation methods, (drainage, surface levelling, stone removal, liming, grass planting and fertilizer application) normal for any given conditions, without which we cannot obtain satisfactory grass yields in most cases.

2) We must consider the specific biological characteristics of perennial grasses of grazing lands and their specific requirements for more moist soils. Consequently, water-logged and bog soils for grazing lands should be rated higher than the same soils used for field crops.

3) The value of meadows and pastures depends also on territorial conditions — size of area, suitability for mechanized removal of hay, mesorelief, etc.

Besides the value of the soil, the size and quality of yield is a general criterion of the present value of a given area.

In Table 2 which we have compiled for meadows and natural pastures, land areas have been divided into 5 groups, according to value of soil and extent of cultivation.

The first and second groups refer to cultivated areas. The best soils are concentrated

Table 2

Evaluation of meadows and natural pastures (value of a hectare in points on a scale)

	Soil characteristics	First hay cutting, cntr/ha[a]	Characteristics of lands and hay quality (grass)								
			A			B			C		
			a	b	c	a	b	c	a	b	c
1	Cultivated (reclaimed, drained and regularly fertilized), and also naturally good areas with good soils, suitable for plowing perennial grasses. Soil reaction from neutral to weakly acid (pH in KCl extract >5.3). Species of soils: granular bottom lands sod-carbonate sod-gley, etc., on clay loam and coarse and medium clay with high content of organic matter, and humic-gley lowland soils.	Above 50	100	80	—	90	72	—	75	60	—
		50-40	90	72	—	81	65	—	66	54	—
		40-30	80	64	—	72	58	—	60	48	—
		30-20 and less	60	48	—	54	43	—	45	36	—
2	Cultivated areas and naturally good areas with soils of average quality. Species of soils: sod-podzolic, gleyish and gley, sod-gley, soils of transitional and stratified bottom lands, and other sandy loam, clay loose rock and fine clay soils, and peat-humic soils of lowland and transitional bogs.	Above 50	80	64	—	70	56	—	55	44	—
		50-40	72	58	—	63	50	—	50	40	—
		40-30	64	51	—	56	45	—	45	35	—
		30-20 and less	48	38	—	42	34	—	34	27	—
3	Non-cultivated or partly cultivated areas with good soils suitable for cultivating grasses. Soils easily susceptible to cultivation.	40-30	27	58	46	64	51	41	52	42	33
		30-20	54	43	34	48	38	30	39	32	25
		20-10	36	29	23	32	26	21	26	20	16
4	Non-cultivated or partly cultivated plots with average quality soils. Cultivation of soils difficult.	40-30	—	45	36	—	38	30	—	29	23
		30-20	—	34	27	—	29	25	—	22	17
		20-10	—	22	18	—	19	15	—	15	12
5	Non-cultivated areas with soils poorly suitable for plowing grasses. Species of soils: typical podzolic, sod strongly podzolic-gley (with ortstein), soils of river-bed bottom lands, etc., sandy, stony and dry mineral soils with a low content of humus, and soils of top bogs.	30-20	—	24	19	—	19	15	—	12	10
		20-10	—	16	13	—	13	10	—	9	7
		<10	—	12	10	—	10	8		7	5

On non-cultivated areas we evaluated them by actual yield; on cultivated plots by yields obtained under given ditions at an average agricultural technology level. The highest yield in Group 1 is 50-40 cntr/ha, while in up 2 it is 40-30 cntr/ha of hay.

xplanation: Land characteristics. A. large areas of land and wide plains and slopes suitable for mechan- d removal of hay (grass). B. Flat and sloping to undulating areas of average size (5-10 ha) generally suit- e for mechanized removal of hay (grasses). C. Small individual areas (found in depressions between hills, slopes, etc.), areas with greatly dissimilar relief and moisture conditions, and poorly suitable for machan- d removal of hay (grasses).

uality of hay (grasses). a. Good hay (grasses) consisting almost entirely of valuable grasses and legumes ntr of hay - 50-55 food units). b. Hay (grass) of average quality, valuable fodder grass, 30%-40% inferior sses and varied grasses (1 cntr of hay = 40-45 food units). c. Inferior hay (grass), consisting chiefly of ge (reed grass), and other poor quality grasses (1 cntr of hay = 30-35 food units).

he first group, average quality soils in the ond.

The third, fourth and fifth groups refer to -cultivated or partly cultivated areas, with ls of different value: in the third group, good ls; in the fourth, average quality soils; and in the fifth, soils barely suitable for meadows and pastures or soils difficult to cultivate. The value of 1 hectare of land, expressed in points on a scale (from 100-5), has been differentiated in each group depending on the quality of the soils and on territorial conditions. The quantity and quality of yields are used as a criterion for evaluating the conditions of a given area. Therefore, on non-cultivated areas we evaluate by actual yield and on cultivated plots by yields that can be obtained under given conditions employing average agricultural methods (about 3 cntr per ha of mineral fertilizers). As experience has shown, the highest yield in the first group is 50-40, on an average, while in the second group, it is 40-30 cntr per ha of hay.

Depending on the value of the soil in each group a minimum number of points has been established that cannot be less even with low yields.

In the future we shall construct a more detailed table by dividing each group into two classes and describing groups of meadows and pastures in each class.

Evaluation Activities and Formulation of Results

It would be practicable to evaluate lands at the same time as soils are being mapped. Then we could use excavated pits and accumulations not only for determining the species and texture of soils, but also for determining soil value.

With large-scale (scale of 1:10,000) soil mapping it is sufficient in most cases to determine the average site index of areas covered by appropriate soil types. In this case all contours on a soil map will correspond to the site index contours on a land evaluation map. Based on useful data, a map showing the quality of land of any given farm can be constructed and the average evaluation computed in points on a scale for a hectare of land — plowed lands, meadows and pastures (even for work-crews areas, separate crop rotation fields, and large meadow and pasture areas).

When soils on a farm have been mapped, we can use the soil map and other cartographic data to construct maps showing the quality of land. We must conduct additional field studies before this can be done more accurately.

It has been proposed that waste lands and shrub-covered areas be evaluated by considering their suitability for transformation into plowed land, meadows or pastures, i. e., by using the same evaluation tables. In several cases it would be best to plant trees on low fertile and hard-to-cultivate areas that are unsuitable for use as plowlands and meadows.

Quality and Productivity of Lands

As we know, the evaluation points on a scale describe the relative quality of land and therefore should reflect the land's relative productivity at one and the same level of agricultural technology. For practical purposes we might consider that in most cases a direct proportion or a straight-line relationship exists between productivity (as a whole, by crop rotation) and the quality of land. If this is the case, we can without great error replace the evaluation points by quantity of yields.

In grouping lands by classes we have also considered productivity. The studies made showed that by using crop rotation on the best plowed lands of the Republic we can obtain an annual harvest from one hectare corresponding to 4,000-5,000 food units, on average grade lands, 2,000-3,000 and on the worst lands, 250-1,000 food units. Therefore, one point on a scale is equal to 50 food units. The same relationship between points and food units has been established for meadows and pastures.

Using the foregoing evaluation tables, in 1957 soil scientists of the Ministry of Agriculture, Latvian SSR, conducted an evaluation of lands at 23 kolkhozes and, in 1958, at 20 sovkhozes and at other farms in different districts of the Republic. Data on the average value of plowed lands in points on a scale, and on productivity (1957) in food units are given in Table 3.

Proper agricultural methods and a high agricultural standard fertilization were employed at experimental stations and, consequently, the actual yield considerably exceeded that computed by points on a scale. In the leading kolkhozes yields also exceeded or corresponded to the computed value, but on economically unstable kolkhozes the actual harvest was only 30%-70% of the number of food units computed according to the value of the plowed lands of these kolkhozes. This shows that these kolkhozes are inefficiently utilizing their own land. As a rule, we could raise productivity on such farms to a level corresponding to the actual site index value of the lands, by using the usual scientific agricultural methods stipulated in the agricultural minimum program. On farms with yields corresponding to the site index value of lands, an increase in yield is possible chiefly by improving lands (melioration, liming, etc.), by using higher agricultural techniques and by selecting more high-yielding varieties of agricultural crops.

Land evaluation makes it possible to analyze the productivity of lands as a whole, and also by separate fields, large areas, and crops. By using other production indicators, e. g., milk and meat production per 100 hectares, monetary return, production cost, etc., we can get a complete picture of the production level of any given farm and also develop ways of subsequently increasing productivity and earning capacity.

Economists, in collaboration with soil

Table 3

Value of plowed lands and yield at several kolkhozes and experimental farms of Latvian SSR

Name of farm	Average value of 1 ha		Actual harvest in food units from 1 ha					Average	% of harvests comp. by points on a scale
	Points on a scale	Food units	Grain	Potato	Sugar beet	Perennial grasses	Ensilage		
1	2	3	4	5	6	7	8	9	10
			Experimental Farms						
Skangali, Yelgavskiy Rayon	65	3250	3400[a]	5380	12800	2543	8162	3743	115
			41.0	5.0	2.0	23.0	3.0	74.0	
Stende, Talsinskiy Rayon	58	2900	3454	7652	—	3185	4000	3878	134
			185.0	30.5		55.5	13.5	284.5	
Priyekuli, Tsesisskiy Rayon	53	2650	3070	5676	—	3472	3710	3567	134
			81.0	21.0		53.5	9.7	165.0	
Potato Station, Rizhskiy Rayon	44	2200	2489	5981	—	2340	—	3168	144
			61.0	24.3		80.0		118.8	
			Kolkhozes						
Avangard, Yelgavskiy Rayon	75	3750	2826	2378	8861	2067	—	3833	102
			417.0	10.5	154.0	191.0		772.5	
Marupe, Rizhskiy Rayon	40	2000	1962	3631	13063	2165	1232	2358	118
			139.0	77.0	4.0	80.0	71.0	371.0	
Imeni Kirova, Vilyanskiy Rayon	38	1900	2005	4760	6138	1378	1649	2015	106
			512.5	50.0	5.0	218.0	36.0	821.5	
Kommuna, Talsinskiy Rayon	44	2200	1729	3909	7233	960	1400	1985	90
			546.5	128.6	36.0	259.4	52.0	1022.5	
Plesums, Talsinskiy Rayon	33	1650	1176	1574	5590	995	1372	1334	81
			107.4	27.0	7.0	57.0	7.4	205.8	
Gaysma, Vilyanskiy Rayon	37	1850	1100	1358	2631	793	980	1073	58
			465.0	40.0	7.0	122.0	18.5	652.5	
Ogre, Ergl'skiy Rayon	40	2000	1188	2618	—	1891	2520	1533	77
			258.5	30.0		107.0	19.5	415.0	
Imeni Lenina Kraslavskiy Rayon	28	1400	1098	2550	—	487	766	1043	74
			602.0	100.0		276.0	32.0	1010.0	
Asuma, Kraslavskiy Rayon	32	1600	805	1496	—	1410	630	972	61
			227.7	16.7		75.0	14.7	334.1	
Imeni Kutuzova, Karsavskiy Rayon	41	2050	630	619	—	702	574	653	32
			496.6	40.0		310.3	31.0	877.9	

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[a] Numerator food units from 1 ha; denominator — sown area in ha.

entists, land developers and other agricul- al specialists, should devote their attention levising a method for consideration of these nomic factors (for determining a differen- ground-rent [I and II], taxes, etc.).

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FORESTRY AND AGRICULTURAL MEASURES TO CONTROL SOIL EROSION IN THE EUROPEAN USSR[1]

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Forestry and agricultural measures to control soil erosion and to protect rivers, reservoirs, bottom land and other areas from silting up consist in the planting of different species of forest, fruit, and nut trees combined with sodding, and building structures to stabilize soils and soil materials and to regulate and stop surface runoff. Forest plantings on slopes and on the steppe are of great importance for wind protection and moisture. On slopes protected by 5 to 7 rows of trees, wind velocity is decreased an average of 40%-50%, evaporation by 20%-25%, and snow contents are increased 30%-35%; depending on the extent of forest planting, runoff is reduced 25%-50% or more (1, 2, 3, 4, 10, 11, 12). For example, observations in the Kamennaya steppe on the effect of tree belts on runoff over a period of 65 years showed that the runoff coefficient was reduced from 0.6-0.96 on the open steppe, to 0.32 when the area had been 6% planted and to 0.14-0.16 in sections where plantings covered 18% of the area (2).

As a result of improving the water and wind regime, grain yield increased 2-4 cntr/ha, grasses (hay) 50%, and in particular years these increased twofold. On the territory of the Novosil'skaya experimental station for forest and land improvement (Orlovskaya Oblast'), grain yields before forest and land reclamation were 3-5 cntr/ha; they have now increased to 20 cntr/ha, and grass harvest (hay) to 40-50 cntr/ha, and on individual tracts up to as much as 70 cntr/ha (3). On land of the Kletskiy experimental gully station (Stalingradskaya Oblast') which had been earlier used as pasture land but later was improved by forestry and agricultrual means, we now get appreciable yields from these soils; for example in 1955, the hay yield of perennial grasses at the experimental station was 20.6 cntr/ha, grain yield was 10 cntr/ha; watermelons used for human consumption, 156 cntr/ha; and watermelons for livestock feeding, 242 cntr/ha. Fruit harvest from anti-erosional fruit plantations were: from pomaceous plantings (apples and pears), 39 cntr/ha; from berry patches (golden currents), 16.7 cntr/ha. Anti-erosion plantations are of great economic importance as a source of wood for construction, fabrication, and fuel. As a rule, areas most subjected to erosion have few forests; for example, the wooded area of the Kurskaya Oblast' is 6.0% (in some rayons of the Oblast' it is even less: in the Shchigrovskiy rayon 2.8%, Sovetskiy rayon, 1.6% Kastorenskiy rayon 1.2%, Cheremisinskiy rayon 0.4%). The wooded area of the Orlovskaya Oblast' is 5.0% and of the Poltavskaya Oblast' (UkrSSR) about 2%. The average wooded area of central-Chernozem regions is 7.3% (4).

Thus, many forest-steppe districts in wooded areas near the dry steppe zone and the 2-6m³ of wood obtainable from 1 ha in a year from anti-erosion plantations under forest mangagement are of great economic importance.

The anti-erosion forest and land improvement measures, considering their erodibility, should form an integral part of the agricultural system and contribute to proper land use. We should divide watershed ravine areas into two groups according to nature of melioration and economic land use. Included in the first group should be the sever ly eroded (and in some cases the medium-eroded) soils, gullies and ravines. The erosion process here is rapid and extends to new areas. Therefore it is important to stop this process and transform the eroded soils, gullies and ravines into valuable lands. The non-eroded, slightly-eroded, and cultivated medium-eroded soils constitute the second group. This is the basic area of concentration for field crop cultivation. Measures are required here to prevent erosion (water-retaining tillage, water-regulating plantations, reinforced whenever necessary by water-retaining terraces).

By such an approach to land use we can bette distribute the different anti-erosional plantations and strips requiring sodding and determine where engineering structures are needed to hol the soil, and to regulate and retard runoff.

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[1] Reported at the First Delegates' Session of Soil Scientists, May 1958.

Recent studies in the field of anti-erosional est and land improvement enable us to in-ease their effectiveness as follows:

Reclaiming Gullies. Observations show that growth of gullies in different zones of the ntry averages 2-5 m annually and in some rs the gully reaches 20 m. However, the maging factor is not so much the eroded lands the lands broken up and ruined by gullies, ich exceed tenfold the areas of actual gullies. erefore, in reclaiming gullies, we must first eck their growth - not by afforestation only, was often recommended (1), but by a combi-ion of structures, (varying, depending upon type of gully, growth rate, and damage done) l afforestation. The purpose of structures is quickly stop erosion and improve conditions reclaiming gullies for forest and fruit plan-ions. The work by spray equipment can be chanized 60%-70%, water-retaining terraces 95%-98%, water-diverting ditches by 70%-%. Such projects as setting up lengthwise and oss fence networks in an alluvial fan zone and ere bank erosion occurs may be mechanized %-50% (Fig. 1).

We can take for granted that forest planta-ns along the bottom of bank gullies and adja-nt areas are of the greatest importance in ms of soil protection and land improvement silt deposition. In many cases gully planta-ns around bank gullies that are very difficult cultivate and not safe from erosion (7) do not ve enough water-regulating significance to tify setting them up. Plantations near and the bottom, which do not narrow but retard water-flow, are very effective, as are gully plantations around bottom gullies combined with sodding of water channels.

Gully plantations are of great economic and meliorative importance. The wood supply on one hectare of 30-40 year-old poplar gully plantations (under comparatively satisfactory moisture conditions) was 500-800 m³ or more. After 32 years Chinese poplar reaches a height of 24.5 m with a diameter (at a height of 1.3 m) of 29 cm (Belgorodskaya Oblast'). On 1 ha of gully plantations (along the bottom and bottom strips) many thousands of cubic meters of alluvium are held in check.

Thus, not only reclamation but also forest economy problems are being solved by stabilizing and afforesting gullies.

Reclaiming Ravines and Ravine Areas. The ravine area occupies a large area. The percentage of ravines in steppe and forested steppe districts is 10%, and in several cases considerably more than the entire land area of these districts. Therefore, a proper use of such an enormous land reserve is of great economic importance. A study of ravines in different districts of the country showed that, as a rule, they are being used impracticably without considering the extent of their erodibility.

We should adhere to the following principles in using the ravine area: namely, to use expediently the slightly-eroded ravines primarily for meadow lands and the eroded ravines for forest and fruit plantations as well as meadows.

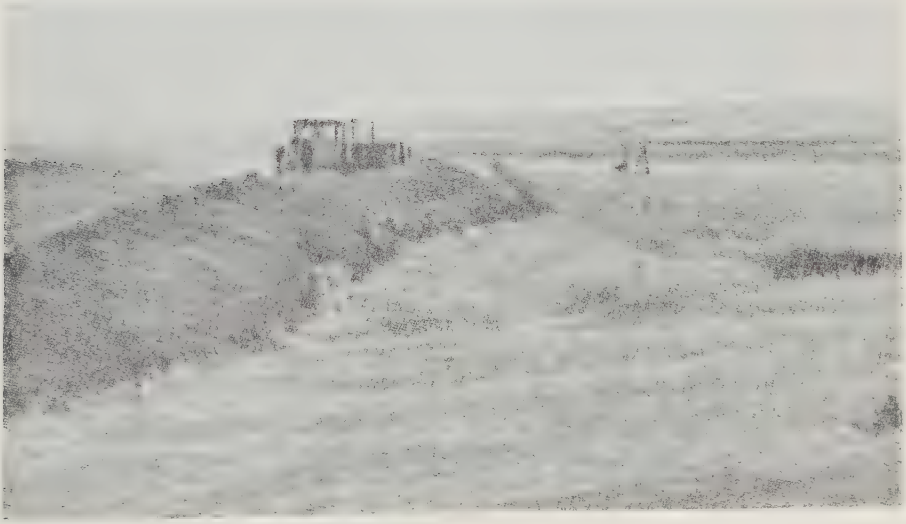

Fig. 1. - Bulldozer construction of a water-retaining terrace above a growing ravine. Experimental base of Povolzhskaya AGLOS (photo by I.D. Braude).

A large portion of the reclamation work in the ravines should be devoted to constructing ponds (5).

Improving meadow and pasture lands is of great economic and anti-erosional importance. In the forest-steppe districts basic surface improvement of dry meadows is very effective. From observations by the Novosil'skaya Experimental Station basic improvement increases the grass yields (hay) three and four fold (up to 80 cntr/ha). Surface improvement of meadows and pastures increases grass yield approximately two-fold. The role of ravine plantations is significant here, especially when straight and convex slopes border ravines. On these slopes, as a result of unequal snow distribution and different thawing rates, the lower slope sections, particularly exposed portions, are subject to severe erosion in the 100-200 m zone from the ravine edge. Under comparable conditions, with ravine forest plantations, erosion of a fall-plowed field is 1.3 m³ from 1 ha; on a control strip, 11.5 m³ (Rakitenskiy rayon, Belgorodskaya Oblast'). The transforming role of ravine plantings can be seen from Figures 2a and 2b.

In the steppe and, particularly, dry steppe districts where droughts occur almost every year, grass cultivation on the banks of ravines is extremely difficult. If measures are not taken here to accumulate moisture in the soil and protect crops from unfavorable weather conditions (by forest strips or connecting rows of shrubs) grasses will grow poorly.

In 1956 we set up an experiment to reclaim the severely-eroded ravine slopes at the experimental base of the Povolzhskaya Experimental Station for forest and land improvement (Kuybyshevskaya Oblast').[2] The soils on the experimental plot were chernozems of low humus content, (southern), fine clay loam, severely eroded. The slope gradient was 4-16° and basic exposure southern. Included in the experiments were measures to stabilize growing gullies and protect reclaimable territory from surface runoff, entering here from above-situated slope sections. Here we also tested excavation equipment for leveling ruts and washouts. Broad base terraces were constructed in these experiments for holding back melted snow and rain water. To protect crops from unfavorable weather conditions, two connecting rows of ordinary June berries and golden currants were planted along the terrace. The distance between terraces was 20-40 m or more. Zhigulevski wheat grass was sown on disked and plowed strips between the terraces.

During the first year of reclamation the wheat grass was planted with spring barley, in the hope that barley would more rapidly form a subsurface mat of runners and improve conditions for growing wheat grass. With the onset of first autumn frosts the barley stalks were destroyed, and formed mulch that protected the soil from excessive dessication; under the extremely dry summer conditions of 1957 the wheat grass yield, converted into hectares, was 5.8-8 cntr/ha on the southern exposure slope and up to 20 cntr/ha on shaded plots. These data point to the possibility of reclaiming severely-eroded soils for grass and forest plantings.

Experiments have shown that broad-base terraces may be constructed with the help of a grader on strips having slopes up to 15°. On banks with 6-8° slopes, terraces have a definite water-retaining capacity. On the steeper slopes terraces appear as stepped-terraces. Their water-retaining capacity can be increased by deeply furrowing the terrace bed.

It has been established that this method of constructing broad-base terraces is the most effective, aided by tractor plow (plowing of the terrace base) and grader (which transfers the soil material to the terrace axis). Grader output on slopes of average gradient is 100-125 m of terrace per hour and on gently sloping ridges (up to 4° slope) 180-200 m. Slope terracing for cultivating forest and fruit plantings has been widely employed in the Stalingradskiy Green District (Fig. 3).

It has also been determined from experiments that construction of water-retaining terraces may be mechanized 95%-98%. For such work one bulldozer operator can take the place of 90-100 diggers. Bulldozer output is 26-35 m³ per hour, depending upon the conditions of soil material displacement and size of terrace. It is important when we transfer soil material to keep the uppermost fertile soil layer intact. This can be done to a certain extent by plowing the area from which the soil has been taken before it is transferred to the core of the terrace. By doing so the upper layer is thrown to one side, and the lower layer can be used to form the terrace core. In one of our experimental variations the upper soil layer was removed and piled up to the side of the terrace being constructed, and after construction the soil was evenly distributed over the area from which it had been taken. Bulldozer output in this work was 493 m² of soil removed per hour. Slopes of terraces may be constructed by a tractor-drawn disk surface plow (6).

Finally, we should point out one very important and effective measure — levelling ruts and wash-outs which at present is being done very little in production. Ruts, left unattended, become wash-outs and these become gullies. As a result, fields become broken-up, there are more detours and microrelief becomes more complex. Our experiments have shown that ruts

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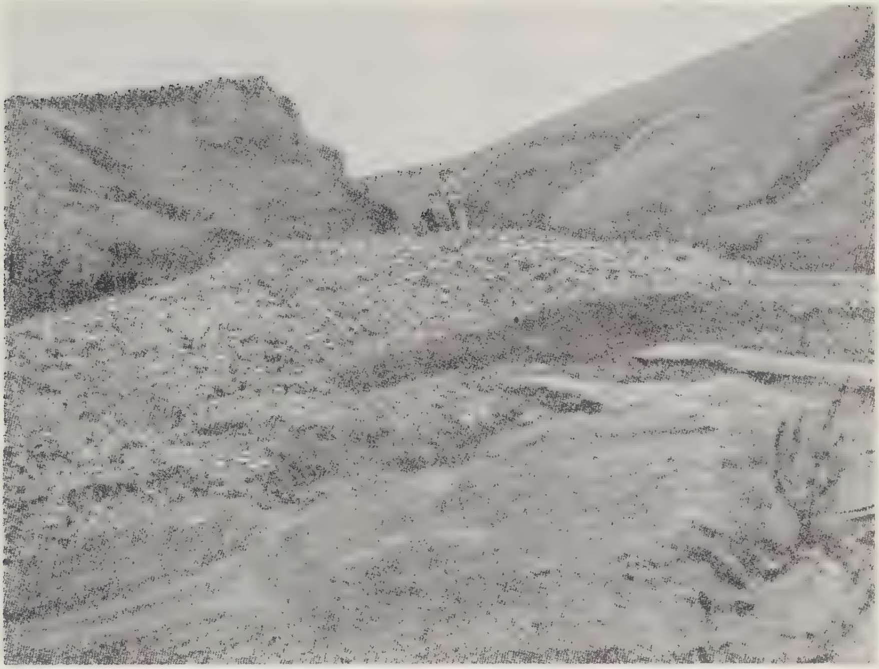
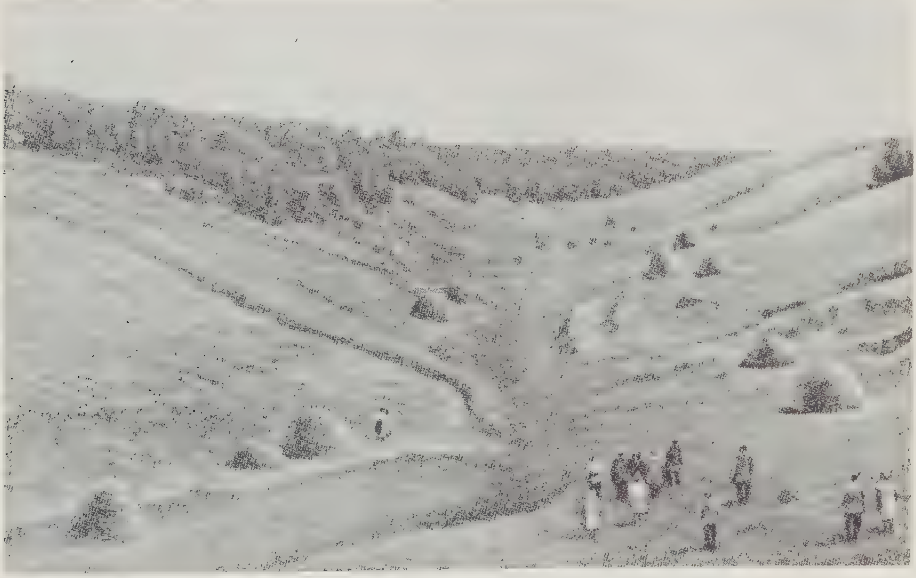
[2] Scientific staff member N.M. Nadezhdina of Povolzhskaya AGLOS, took part in the observations and in setting up the experiment.



a



b

Fig. 2. - Mouth of the eroded ravine "Odinokskaya"

a - before reclamation. In the foreground detritus (crushed stone) and eroded alluvium on a river meadow (1925) (Photo by the Novosil'skaya Experimental Station); b - after anti-erosional forest and land reclamation (1953) (Photo by G.R. Eyntingen) may be successfully levelled, and the wash-outs completely or partially filled. Included in this work is the temporary removal of runoff from the wash-outs, or holding the runoff above the wash-outs. If runoff conditions are not changed, surface waters will continue to flow towards the filled wash-outs and wash away the terrace soil.

We can fill ruts up to 0.4-0.5 m wide and 0.4 m deep with a tractor plow, but larger size ruts must be filled by a bulldozer. In our experiments levelling of ruts 1 m^3 took, on an average, 21.5 seconds. It is often expedient to fill (level) large wash-outs only partly, rather than completely, thereby constructing an area convenient for transporting machines and equipment, and to form ponds.

Bulldozer output in partly filling a wash-out (by sloping the edge and sides) is 96-121 m^3 per hour; when entirely levelling wash-outs and shifting soil 25-30 m distance, bulldozer output is 30.7 m^3 per hour. When levelling wash-outs we should take care to preserve intact the upper fertile soil layer.

It has been estimated that the work in levelling wash-outs is 5-6 times less than the time lost by going around them when cultivating soil and harvesting during the course of a year.

Water-Regulating Plantations. Depending upon the size of the watershed ravines and also on the length and type of slope profile, water-regulating forest and garden strips are created to supplement the foregoing anti-erosional forest and land improvement measures. They extend their effect also to the areas used for field crops (second land category — the non-eroded and slightly-eroded soils).

The principles involved in approaching the spacing of water-regulating forest and forest-garden strips, which are the same principles as in their construction, demand more precise data on soil-climatic conditions, relief, and exposure, of the areas where these plantations are to be created. The site and size of forest water-regulating strips must be determined, taking into consideration the character of snow distribution, snow-thaw, runoff formation, erosion development, and also scientific agricultural methods used to check runoff on areas between strips (3, 4, 8, 9, 10, 11, 12).

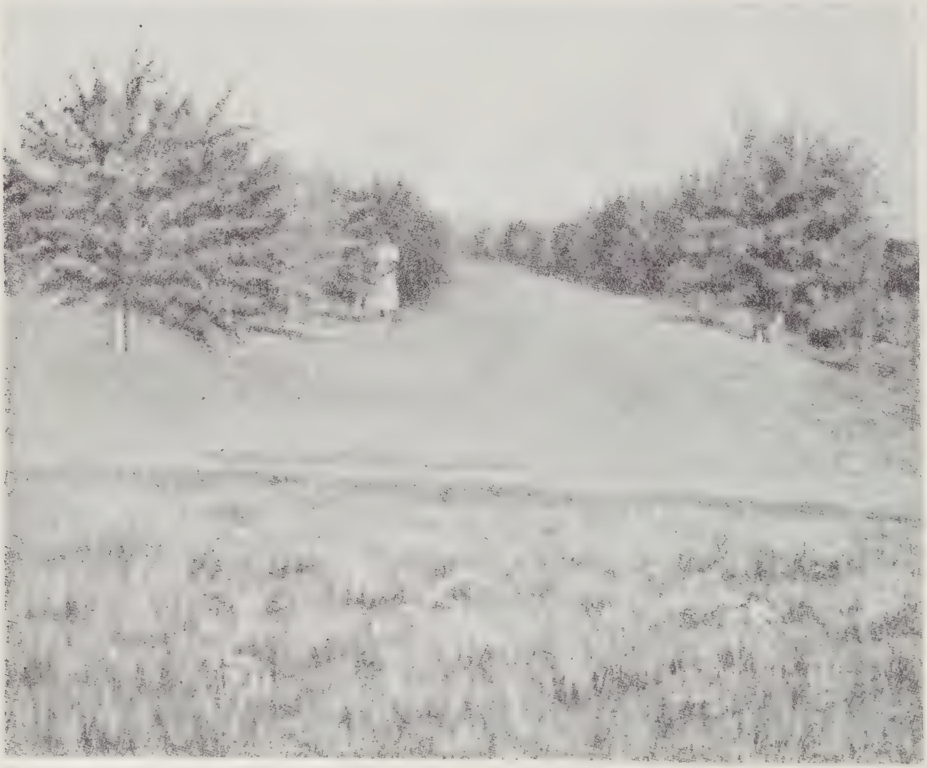


Fig. 3. - Broad-base terrace built with a grader. Territory of Povolzhskaya AGLOS. (Photo by I.D. Braude).

From observations on the effect of water-
ulating forest strips on snow distribution and
off we may conclude that these strips should
be built close together. In the forest-steppe
ricts the water-regulating strips should be
out primarily so as to permit the wind to
through, while in the steppes these should
pen structure. The water-regulating plan-
ons, like the other anti-erosional plantations,
uld be created from fast-growing tree spe-
. The meliorating effect will then be seen
ng the first 3-4 years and will increase each
r thereafter.

t has also been determined from experimen-
research work that to heighten the water-
ining and water-regulating role of forest
tations we must guarantee a free and dis-
sed entry into the forest strip (plantation) of
ace water, and also provide for their pas-
e through the plantations. To do this, we
t carry out measures to level off the surface
elds (fill ruts and wash-outs) and also dis-
se and stop runoff on fields and in forest
tations. We must also sod the hollows
ve forest plantations and build diversion
ctures here.

n the next 7-10 years we must conduct an
-erosional forest and land reclamation
gram for an area of about 15 million hectares
roded land. This will enable us to use lands
e productively, curtail erosion processes,
revent entry into rivers and onto cultivated
ls of millions of tons of alluvial deposit which
up water systems, meadows, orchards and
r valuable lands, obtain 6-8 million hectares
igh quality pastures and hay fields, 5-6 mil-
hectares of reclaimed lands suitable for
ting grain and other agricultural crops and
ut 1.5 million hectares of valuable forest,
t and nut plantations. We can construct at
t 15-16 thousand ponds in ravines with a
er area of 150-170 thousand hectares.

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RESTORATION OF FERTILITY OF ERODED GRAY-FOREST SOILS BY MEANS OF FERTILIZERS (According to Field Experiments)[1]

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The crop yield from eroded soils is decreased from 30%-60% depending on the degree of erosion (4). It is estimated that eroded soils comprise almost 30 million hectares in the European part of the USSR alone. Restoration of fertility of these eroded soils is an important national problem. Very few experiments were conducted to study the effect of fertilizers on crop yield increases in eroded soils. Such data on gray-forest soils exist in only three investigations (1, 3, 4).

Plots with eroded soils are characterized by variegated top soil inasmuch as soil erosion does not occur in a uniform layer but in rills which are subsequently plowed. This forms a difficulty in conducting experiments with such soils. Plots with a definite degree of erosion usually occupy small areas; therefore, we laid out control plots alongside each plot and adopted two treatments in the experiments. These were started in 1954 at the field of the Moscow State Agricultural Station in Serebryanaprudskiy, rayon, Moscow Oblast' (Uzunovo village). The length of the experimental area was 60 m.

The area was located in the lower part of a slightly prominent 5° slope with a northwest exposure. The soil was a fine-clay loam gray-forest soil, moderately eroded and cultivated. Winter wheat was sown after black fallow. The experiment was replicated four times with treatments as follows: 1.20 metric tons of manure + Ps_{40} per hectare; 2.3 metric tons of manure + Ps_{40} + 5 metric tons of lime per hectare.[2] The size of the test plot was 2.5 x 20 = 50 m^2.

Two soil profiles were taken in different directions to determine the character of the soil several meters from the experimental area and analyses were conducted of the soil samples taken from the plowed layer of each plot to explain a possible variation in nutrient content. The data in Table 1 indicate a slight humus content in the plowed layer and a sharp decrease in content in the B horizon. The soil is not rich in available phosphorus but the available potassium contained in it is sufficient for crops.

Determination of nutrients and acidity in the field that was formerly under fallow (Table 2) indicated that the pH value varied generally from 4.8-5.0 before fertilizer was added to the plots. The phosphorus content variation is greater but the average values are sufficiently close to one another. The difference in potassium content is small and the nitrate content variation, although significant, is permissable for this very available compound; moreover th average values are equalized.

The yield data (Table 3) indicate that addition of a full amount of manure with phosphoru has a rather significant effect in increasing yields not only on the first crop, but also on the succeeding ones. The yield increase was close to 20% for the three years of the experiment.

The effect of a triple mixture, recorded in the first year of the experiment, is considerably less. As a consequence, this effect appeared in the third year in a clover and timoth grass mixture which is probably explained by the liming conducted during the first year of th experiment.

The second experiment in fertility restoration of eroded soils was conducted on a south slope of the XIX Party Congress Kolkhoz in Kashirskiy rayon, Moscow Oblast' in the fall of 1956. The experiment was laid on a dark gray-forest soil which, for the previous four years, was under a grass mixture. The soil was slightly eroded in one area in the central portion of the 2° slope while at another area in the lower portion at a 5° slope the soil was moderately eroded.

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[1] Presented at the First Delegates' Conference of Soil Scientists, May 1958.

[2] Phosphorus was added in the form of a superphosphate (Ps).

Table 1

Several chemical indices of a moderately eroded gray-forest soil
(E. M. Rozenblyum, Analyst)

Profile No.	Location	Horizon	Depth, cm	Hygroscopic moisture	Humus (Tyurin method)	P_2O_5 (Kirsanov method)	K_2O (Maslova method)
				% of absolutely dried soil		mg/100 g of soil	
31	5 m towards the NE from the experimental area 5° slope, NW exposure	AB	0—10	2.8	1.80	7.9	19.8
		B_1	25—30	3.8	0.71	10.2	20.0
		B_2	50—55	4.1	0.60	10.9	18.8
32	5 m towards the SW from the experimental area. Slope and exposure are the same	AB	0—10	2.6	1.92	5.7	19.6
		B_1	35—40	4.0	0.77	2.7	20.7

Table 2

Nutrient content in a moderately eroded gray-forest soil (moderately cultivated) and soil acidity before fertilizing

Treatments	Depth, cm	Range throughout four plots	Average
Nitrates (NO_3), mg/kg of soil. Disulfophenolic acid method.			
3 met. tons man. + Ps_{40} + 5 met. tons lime	0—20	35.8—93.5	69.8
Control	0—20	51.5—81.3	64.5
20 metric tons manure + Ps_{40}	0—20	60.9—83.7	70.6
Phosphoric acid (P_2O_5) by Kirsanov method, mg/100 g of soil			
3 met. t. manure + Ps_{40} + 5 met. t. lime	0—20	5.0—7.5	5.8
Control	0—20	5.0—7.5	5.9
20 metric tons manure + Ps_{40}	0—20	6.2—7.5	6,5
Potassium (K_2O), mg/100 g of soil. Ammonium acetate method			
3 met. t. manure + Ps_{40} + 5 met. t. lime	0—20	15.0—20.2	17.5
Control	0—20	15.0—19.3	17.1
20 metric tons manure + Ps_{40}	0—20	16.8—19.3	17.7
Acidity (pH) in a salt extract			
			Range throughout four plots
3 met. t. manure + Ps_{40} + 5 met. t. lime	0—20		4.8—4.9
Control	0—20		4.8—5.0 (6.0)
20 metric tons manure + Ps_{40}	0—20		4.8—5.2

Table 4 shows the differences between the
-eroded soil of a watershed and soils of
ying degrees of erosion. The humus con-
in the plowed layer of a non-eroded soil
lose to 3%, in a slightly eroded soil — 2.5%,
in a moderately eroded soil — 2%. The
ius content in the subsoil in eroded soils
ps sharply and is only half the amount of
that of a non-eroded soil at the same depth.

Data on the soil nitrification is interesting. An experiment was conducted during an 18-day period at a temperature of 25° -28°C. During this period the nitrate content in the upper layer of a non-eroded soil increased from 10-36 mg per kg of soil; in a slightly

Table 3

Effect of fertilizing on the crop yield in a moderately eroded, fine-clay loam, cultivated gray-forest soil

Treatments	Range throughout four plots	Average	Increase	
			cntr/ha	%
Grain yield of Khar'kovskaya 917 winter wheat, 1955, cntr/ha				
3 met. tons man. + Ps_{40} + 5 met. tons lime	24.3—27.4	25.5	1.5	6.2
Control	22.4—25.8	24.1	—	—
20 metric tons manure + Ps_{40}	27.0—31.8	28.6	4.5	18.7
Grain yield of "Pobeda" oats, 1956. Result of fertilizing in cntr/ha				
3 met. tons man. + Ps_{40} + 5 met. tons lime	15.3—20.9	17.9		
Control	15.9—22.1	18.6	—	—
20 metric tons manure + Ps_{40}	17.5—25.5	22.6	4.0	21.5
Grass (clover + timothy) yield 1957. Moist weight. Result of fertilizing in cntr/ha				
3 met. tons man. + Ps_{40} + 5 met. tons lime	78.0—91.0	83.1	4.6	5.9
Control	78.0—79.6	78.5	—	—
20 metric tons manure + Ps_{40}	96.0—96.3	96.3	17.8	22.7

Table 4

Several data of the analysis of a dark gray-forest soil (E. M. Rozenblyum and A. P. Kulakova, Analysts)

Degree of soil erosion	Slope	Horizon	Depth, cm	Humus, % (Tyurin method)	Nitrification capacity, Nitrate N mg/kg		Adsorbed cations, meq		Particle diameters <0.01 mm
					Before the experiment	After the experiment	Ca^{++}	Mg^{++}	
Non-eroded	0.5°	A_p	0—10	2.78	10.4	35.6	14.2	3.0	40.7
		A_1'	25—30	1.84	1.6	5.8	16.3	3.3	—
		A_1''	35—40	1.46	1.5	Traces	—	—	—
		B_1	45—50	1.07	1.2		12.2	4.4	46.2
		C_2	170—175	—	—	—	—	—	57.4
Slightly eroded	2°	A_p	0—10	2.48	3.3	7.6	14.2	2.9	41.5
		B_1	30—35	0.86	Traces	3.6	19.1	4.9	51.5
		B_2	45—50	0.61	Traces		21.1	5.3	—
		B_4	100—105	—	—	—	19.1	3.9	—
Moderately eroded	5°	AB_p	0—10	1.96	3.1	2.4	14.0	3.2	38.6
		B_1	25—30	0.71	Traces		18.6	3.0	51.1
		B_2	40—45	0.65			18.8	4.0	—
		B_3	95—100	—	—	—	19.6	3.6	—

eroded soil from 3-7.5 mg; while in a moderately eroded soil the nitrate content did not increase. The soils in question are similar with regard to the sum of the cations adsorbed; the sum in the B_1 horizon was somewhat greater in eroded, finer-textured soils.

We adopted only three treatments to consolidate the experiment: N, O, NP, and NPK (this order corresponds to the plots in the experimental area). With this arrangement each plot with N and NP had a common border with a control plot, while the plot with the full amount

Table 5

Effect of fertilizers on the yield of Liutestsens 62 spring wheat in a slightly cultivated, dark gray-forest soil with different degrees of erosion

Treatment	Slightly eroded soil							Moderately eroded soil						
	Yield, cntr/ha					Yield increase		Yield, cntr/ha					Yield increase	
	n	M	m	Sign. diff. metric tons	$\frac{p}{2}$	cntr/ha	%	n	M	m	Sign. diff. metric tons	$\frac{p}{2}$	cntr/ha	%
N	4	14.99	0.54	4.90	0.5	3.3	28	4	11.54	1.33	4.16	0.5	5.7	98
O	4	11.73	0.39	—	—	—	—	4	5.79	0.40	—	—	—	—
NP	4	15.25	0.054	6.52	0.27	3.5	30	4	11.73	0.58	12.12	0.14	5.9	100
NPK	4	**15.26**	0.65	4.65	0.5	3.6	31	4	12.73	0.41	12.05	0.14	6.9	119

Table 6

Yield of Liutestsens 62 spring wheat in an experiment with fertilizers

Treatment	Slightly eroded soil				Moderately eroded soil			
	No. of grs. per spikelet (aver. from 100)	Spec. wt. of a grain (aver. of two replicates)	No. of spikelets per m²	Spikelet length, cm (aver. from 100)	No. of grs per spikelet (aver. from 100)	Spec. wt. of a grain (aver. of two replicates)	No. of spikelets per m²	Spikelet length, cm (aver. from 100)
N	16.5	32.01	204	5.07	12.5	30.80	196	4.16
O	13.7	31.47	175	4.58	7.6	29.66	173	3.00
NP	18.8	32.32	215	5.27	15.8	31.14	184	5.58
NPK	20.2	33.53	229	5.53	18.3	31.68	194	5.62

ertilizer bordered the plot with N. Thus the ion of the PK (in comparion with its neigh- ing plot) could be examined with the basic ogen fertilizer.

The test areas were divided into slightly ded and moderately eroded soils; these were ther divided into 5 x 25 = 125 m² plots hav- a calculated area of 2.5 x 10 = 50 m². The eriment was replicated four times. There e 16 plots in each area. The length of the erimental area was 80 m.

A determination of the humus, available sphorus and potassium contents, as well he acidity (pH) in the 0-5 cm layer indi- ed that a relative homogeniety of the plowed er in the different plots was maintained. The ius content in the plots containing the slight- roded soil varied within 2.7%-3.1%, while in plots containing the moderately eroded soil aried within 1.9%-2.2%. Available phos- rus per 100 g of soil, as determined by the rikov method, amounted to 6-8 mg in the htly eroded soil and 4.5-7 mg in the moderately eroded soil. Potassium content per 100 g of soil in the slightly eroded soil was 14-16.5 mg, while in the moderately eroded soil it was 18.5-23 mg; the pH value of a salt extract in the slightly eroded soil was from 5.5-5.6 and in the moderately eroded soil from 5.4-5.8. Thus the soil reaction approached neutral in both areas.

The fertilizer rate was: N_{45}, P_{90}, and K_{45}. The potassium fertilizer and half of the phosphorus fertilizer were added in the fall, while the nitrogen fertilizer and the second half of the phosphorus fertilizer were added in the spring during cultivation. The entire field was then seeded with Liutestsens 62 spring wheat.

As we see from Table 5, the yield increase is much greater in the moderately eroded soil than it is in the slightly eroded soil.

The use of fertilizers in moderately eroded soil is fully justified and proves more effective than in a slightly eroded soil. The difference in yield decreased with use of fertilizers. Nitrogen proved to have the greatest effect in increasing yield in both areas; even potassium produced a significant yield increase in the moderately eroded soil. Data developed by a method of variation statistics (Table 5) show that the difference between the yield in the plots with fertilizers and the yield in the control plot is significantly high.

We see from the yield data (Table 6) that the difference in yield in soils with different degrees of erosion and in plots with fertilizers is primarily explained by the difference in the number of grains per spikelet and in the length of the spikelets. The specific grain weight and the number of spikelets per unit area have a lesser importance.

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Conclusions

1. The use of organic and mineral fertilizers on eroded soils greatly increases the yield (20%-30% in the case of moderately cultivated and up to 100% in slightly cultivated, moderately eroded soils).

2. Crop yield is increased very highly in moderately eroded soils so that it approaches the yield in slightly eroded soils; the use of a fertilizer here is justified to the highest degree.

3. The greatest yield increase results from a nitrogen fertilizer; the addition of a phosphoru fertilizer increases the yield even more; potassium has a noticeable effect only in a moderatel eroded, slightly cultivated soil.

4. The significant crop yield increase in eroded soils by an addition of fertilizers demonstrates that, in many cases, it is possible to restore the fertility of eroded soils by control erosion methods and a high degree of agricultural practices so that the soils will not be excluded from useful crop rotation.

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SALT REGIME OF THE SOILS OF CENTRAL BARABA WITH REFERENCE TO THEIR DRAINAGE

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The Baraba lowland is a part of the great Western-Siberian lowland, situated in the western part of the Novosibirskaya Oblast' in the district between the Ob' and Irtysh Rivers. It occupies an area of 11.7 million hectares; approximately 34% of the area is bog and waterlogged soil; 24% natural meadows and pastures; 10.6% forests and shrubs with only about 15% plowed land.

Typical of the Baraba lowland is the extensive development of the salinization processes. Nearly 40% of the total area is covered by soils having varying degrees of salinity within the Baraba, including almost 1.7 million hectares covered by strongly salinized soils — the solonchaks.

Under Baraba conditions salt accumulation n the soil is due chiefly to soil formation processes, past and present, and to mineralization of plant residue. (9). The salinization rate of soil and ground waters in Baraba is intensified n the direction of a common local slope gradent running from the north and northeast towards the south and southwest, from practically nonsalinized soils (peat bogs 0.1%-0.3% and mineral soils 0.2%-0.5%) in the north to strongy salinized soils (peat bogs 1%-2% and mineral soils 5%-10%) in the south and southwest (8). The chemistry of salinization also changes in he same direction. In the north and northeast he bicarbonate alkali earth salts are predominant; the amount of sulfates and chlorides (1) increases towards the south and southwest.

A widespread distribution of sodium carbonate in Baraba (3) soils is explained by the acivity of sulfate-reducing bacteria. Under anaerobic conditions with an abundance of organic matter in the presence of sodium salts the baceria reduce the sulfates to the sulphides, which react with CO_2 of soil and water, forming sodium carbonate together with hydrogen sulphide.

With the general movement of salts in the soil and ground water on the Baraba along a common slope gradient we observe a clearly expressed degree of soil salinization based on topography. The nonsalinized and slightly salinized soils are found on the better drained mineral soils, situated on the higher elevations, on watershed plateaus, and also the peat-bog soils with a thicker peat layer more than 0.5 m in depth. Soils of regions adjoining the bogs in the bog zone are the most salinized. The salt accumulations in the soil and the formation of salinized soils on the individual elements of the relief are brought about by ground waters lying close to the surface and by local runoff waters as well as by climatic and geomorphological conditions, geological structure, water-logging and vegetation.

Large areas of bogs and water-logged soils in the Baraba are the principal available land for enlarging the livestock and for raising the agricultural level in this subdistrict. It has been established that improvements in drainage together with scientific agricultural measures in reclaiming peat-bog soils, guarantee high stable yields of the basic agricultural crops on these lands even during driest years. After draining the Karapuzskiy bog area of Ubinskiy rayon on the reclaimed peat-bog soils on the Kolkhozes "Banner of Communism," Stalin and "Hero of Labor," the following yields were obtained from one hectare during 1951-1955: 54-61 cntr/ha of hay from perennial grasses; 46 cntr/ha of a vetch-oat mixture; 17-23 cntr/ha of oats and winter rye; 175 cntr/ha of potato, and 300-350 cntr/ha of green ensilage sunflower.

To introduce the bogs and water-logged soils into the economic cycle we must undertake reclamation measures that will provide for the removal of excess water and regulate the water table; this will basically change the water-air regime of the soil and will have an effect on the rate of the soil-forming process.

One of the principal problems in improving and agriculturally reclaiming the Baraba bogs is the control of salinization and the prevention of secondary salinization.

This article discusses the results of studying the salt regime of soils in connection with reclaiming bogs in the central part of the Baraba lowland. The problem of the effect of drainage on the salt regime of Baraba soils has concerned many investigators (2, 4, 5, 10, 11, 12, 13, 16) but their data conflict: in some cases after reclamation an intensification of the salinization of bog soils and ground waters is noted; in other cases a salinization of the upper horizons of the soil and of the ground water is observed. This contradiction in the results is explained, apparently, by the specific characteristics of the natural conditions (climate, geomorphology, hydrology, etc.), and also by the differences in the properties of the soil material, macro and micro-relief, heat regime, etc. It is possible that investigative methods used also played a part. A further study of this problem is of great practical importance in controlling salinization.

A study of the seasonal dynamics of the salts of solonchak-like bog soils at the Ubinskaya Experimental Station for Melioration (6, 7) showed that the migration of salts together with soil moisture is subject to great seasonal variations. During the winter, moisture is accumulated in the soil when it is frozen and the salts are drawn into the upper layers; during the summer as the soil begins to thaw, together with the downward flow of water, the salts are removed and the upper soil horizons become desalinized.

In experiments with mole drainage and subsoil shattering (15) on meadow solonchak it was shown that during a vegetation period these measures contributed to a more rapid percolation of precipitation into the lower soil layers and to desalinization of the upper soil horizons.

After the construction of the Karapuzskiy Canal had been completed and agricultural reclamation of the drained lands had been begun by the Kolkhozes, we participated (from 1950-1956) in the work of the Baraba expedition of VNIIGiM and conducted studies of the salt regime of drained peat-bog soils and mineral soils adjoining the bog. The objectives of these studies were to determine the rate of change during the salt regime and the degrees of salinization of plowed and subplowed layers in the drained soils.

As a subject of study we selected the bog in the Karapuzskiy swamp depression basin (subject to seasonal inundation) on the kolkhoz "Banner of Communism," Ubinskiy rayon, and adjoining the bog in the bog zone and on the elevated elements of the relief. Botanical composition of the bog is basically reed-sedge. Bog belongs to a group of slightly-salinized bogs of the chloride-sulfate type. The thickness of the peat layer at the center of the bog is 150-200 cm and decreases towards the periphery to 30 cm. The bog surface is covere with hummocks consisting of an interweaving root system of peat sedge. The height of the hummocks is 40-50 cm, with 30,000 or more on one hectare. The infiltration coefficient for the upper layer of bog (0-25 cm) equals, on an average, 0.00675 cm/sec. Calcareous clay with an inclusion of fresh-water shells is the layer lying under the peat.

In the bog zone the soils are basically a meadow solonchak of a chloride-sulfate type of salinization, while on the higher topography the soils are slightly salinized chernozem — meadow soils.

Studies were made along two profiles which include all the basic elements of the relief — bog, along the bog area and crest.

A bog strip in Profile 1 (Line 1) up to 1956 following construction of the main open drainage network remained unreclaimed, while agricultural crops were planted in 1951-1956 on a bog strip in the Second Profile (Line II) after construction of the main open drainage network combined with a closed network (slit drainage). The land in the bog area was used as natural meadow land, while on the higher topography agricultural crops were grown. During this period observations were made along the profiles (Lines I and II) for the depth of the water table and soil samples were periodically taken near individual Observation Wells to analyze salt composition.

Soil samples to be analyzed were always taken at the end of July to eliminate the effect of season on the salt regime of the soil (keeping in mind the considerable vertical migration of salts in the soil at various times of the year). Solid residue, CO_3, HCO_3, Cl, SO_4, Ca, Mg, and Na by difference were determined in the water extracts from soil samples at a depth of 0-20 and 20-40 cm.

To show the characteristics of the meteorological conditions and the regime of ground waters, Table 1 gives data on precipitation and water levels for the vegetative periods 1950-1956, and shows monthly and annual total precipitation. From these data on total annual precipitation we see that a study of the salt regime of soils coincides with severe drought periods in Baraba. In the period 1950-1956, four years (1950-1952 and 1955) were characterized by severe droughts; in the moist years, 1953 and 1956, precipitation was 28% and 47%, respectively, over the 24-year mean, while in 1954 precipitation almost equalled the annual 24-year mean. During dry years in the Barab the level of ground waters dropped to a consid-

Table 1

Total precipitation by year and month for 1950-1956 from data of the Ubinskaya Meteorological Station (mm)

Months	Years							24-year-mean
	1950	1951	1952	1953	1954	1955	1956	
January	5.1	4.5	2.2	18.3	9.1	11.6	18.8	8.7
February	4.1	4.5	0.9	8.0	9.3	18.0	2.8	6.8
March	10.7	4.0	6.2	34.3	15.0	6.9	7.7	9.6
April	20.7	7.4	21.3	3.2	2.9	6.4	30.7	15.5
May	23.2	9.9	3.5	17.9	30.2	7.7	46.8	27.6
June	34.3	42.4	32.5	131.9	49.0	2.4	82.7	53.2
July	50.4	42.3	25.7	59.3	66.6	27.9	77.8	69.2
August	29.8	25.4	39.4	54.5	52.0	34.3	133.7	53.3
September	41.7	13.3	21.7	22.4	33.3	55.7	40.2	42.7
October	14.8	18.6	61.6	50.7	18.5	14.4	43.1	27.6
November	7.6	10.3	15.3	17.4	36.0	14.0	5.3	15.0
December	10.7	11.6	42.8	22.3	3.0	23.3	13.1	12.6
Total by year	253.1	194.2	276.1	440.2	324.9	222.6	502.7	341.8
Total for Jan. -June	98.1	72.7	66.6	213.6	115.5	53.1	189.5	121.4
Total for vegetation period, May-September.	179.4	133.3	122.8	263.8	231.1	128.0	381.2	246.2

able depth and the upper soil layers dried, ich shows the effect of salt dynamics in soil.

In order to compare the salt dynamics in the per root layer of soil with precipitation and gime of ground waters, Table 2 gives the nimum and maximum water tables by proes in the summer for the period under study. e data for 1950 were obtained before drain; the bog.

The water table depends to a great extent on precipitation and varies widely by months. e highest level of the water table was noted 1950 before draining the area. The maxim reduction in the level of the water table gins towards fall. For example, on the bog rofile 1) in the dry year 1952 the level of ound waters dropped in September to 175-9 cm, while in the heavily wet year of 1956 dropped to 125-137 cm.

In Figures 1 and 2 we see the depth of the ter table from Profiles 1 and 2 during sepate years; the minimum level is in May and ne, the maximum in August-October.

The results of determining salts in the soil om the first profile (Line I) are given sepately for bog, along the bog area and eleed elements of the relief in Tables 3 and 4, d 5. From these data we see the sharp ference in the degree of soil salinization. ainage has a substantial effect on the salt gime of the upper root layer of soil, mainly on the bog and along the bog area. On the bog (Table 3) we observe a constant salt accumulation in the upper soil layers. The percentage of solid residue is increased owing to calcium and magnesium sulfates. The amount of bicarbonates and chlorides decreases and only at Observation Well No. 10 in a 0-20 cm soil layer is there an increase of Cl from 4.91 meq in 1950 to 5.91 meq in 1956; at Well No. 5 in a 20-40 cm soil layer HCO_3 increases from 1.25 meq in 1950 to 5.16 meq in 1956. In addition, at Observation Well No. 10 in a 0-20 cm soil layer the percentage of Na increased from 21.80 meq in 1952 to 28.23 meq in 1956 and in a 20-40 cm soil layer the percentage increased accordingly from 20.94 meq to 21.25 meq. Along the bog area (Table 4) we also noted an increase in salt content in the upper soil layer due to chlorides and sulfates, chiefly. This is expressed particularly sharply with Observation Well No. 13 in the dry year 1952 after the two preceding dry years. Here in a 0-20 cm layer the Cl content increased from 7.86 meq in 1950 to 17.03 meq in 1952; SO_4 increased accordingly from 33.60 meq to 62.83 meq and Na from 11.95 meq to 74.31 meq, while in the 20-40 cm soil layer the Cl content increased from 3.93 meq in 1950 to 9.01 meq in 1952; the SO_4 content increased accordingly from 27.77 meq to 38.12 meq and Na from 6.20 meq to 42.18 meq. In the wet year 1956 desalinization was observed in the upper 0-20 cm soil layer and a decrease in the content of Cl, SO_4, and Na as compared with the content of these in the dry year 1952 which, obviously, is caused by the

Table 2

Water tables after drainage from Profiles 1 and 2 in centimeters from the surface

Month	1950		1951		1952		1953		1954		1955		1956	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Profile No. 1 on bog														
June	13	27	91	95	106	125	85	not det.	63	80	130	143	102	117
July	28	50	125	178	117	149	91	114	68	77	144	147	125	142
Aug.	67	73	135	147	155	169	109	123	70	93	150	154	140	148
Sept.	50	68	150	155	175	180	123	125	73	90	142	152	125	137
Along the bog area														
June	5	27	156	116	172	185	158	209	156	162	103	114	195	204
July	31	60	173	193	180	191	155	170	146	166	114	122	200	214
Aug.	60	77	197	210	199	204	175	190	176	196	122	132	203	214
Sept.	55	82	225	—	222	224	172	180	183	194	129	135	190	200
On slope on elevated elements of relief														
June	33	60	115	127	128	162	187	207	93	101	115	125	123	124
July	56	72	152	179	168	190	172	176	88	124	131	149	130	144
Aug.	56	69	200	215	187	196	170	183	132	144	153	155	145	157
Sept.	67	74	220	226	230	237	Not determined				197	203	Not det.	
Profile No. 2 on bog														
June	Not determined				118	128	Not det.		88	108	97	117	114	124
July	46	58	83	90	104	117	61	96	88	100	119	130	123	129
Aug.	47	52	73	88	105	113	83	110	99	111	128	140	127	137
Sept.	38	44	93	95	109	115	97	107	118	125	135	142	121	131
Along the bog area														
June	Not det.		61	93	80	105	Not det.		68	76	96	130	118	160
July	61	64	121	130	54	116	69	107	64	108	142	145	132	157
Aug.	91	99	133	144	127	143	112	138	119	141	165	174	159	169
Sept.	58	81	148	162	157	160	139	140	70	87	175	178	160	171
On slope on elevated elements of relief														
June	Not determined				40	100	—	73	48	62	50	107	95	125
July	80	85	50	71	57	107	—	82	46	96	116	120	130	150
Aug.	74	83	108	137	116	142	93	112	108	123	154	169	151	165
Sept.	73	85	152	168	145	153	107	111	113	131	169	172	141	155

removal of salts into the lower layers of soil by precipitation. On the slightly salinized soils of the elevated elements of the relief (Table 5) we do not see a change in the salt regime of the upper soil layers associated with drainage.

The data obtained from Profile 2, situated approximately 3 kilometers southwest of Profile 1, is given in Tables 6 and 7. From this we see that on the bog and along the bog area from Profile No. 2 there is not a sharp difference in the degree of salinization of the upper soil layer, as was observed from Profile 1 (Table 3, 4) where the soils on the bog have been salinized considerably less than those along the bog area; this is explained, apparently, by the difference in the relief of the area and by several other reasons. The character of the changes in the salt regime in Profile 2 differs little from the change in the salt regime of the soil in Profile 1. Here on the bog in the 0-20 cm soil layer (Wells 3, 5, 7) we note an increase in the sulfate contents of Ca, Mg and Na, and at Wells 5 and 7 there

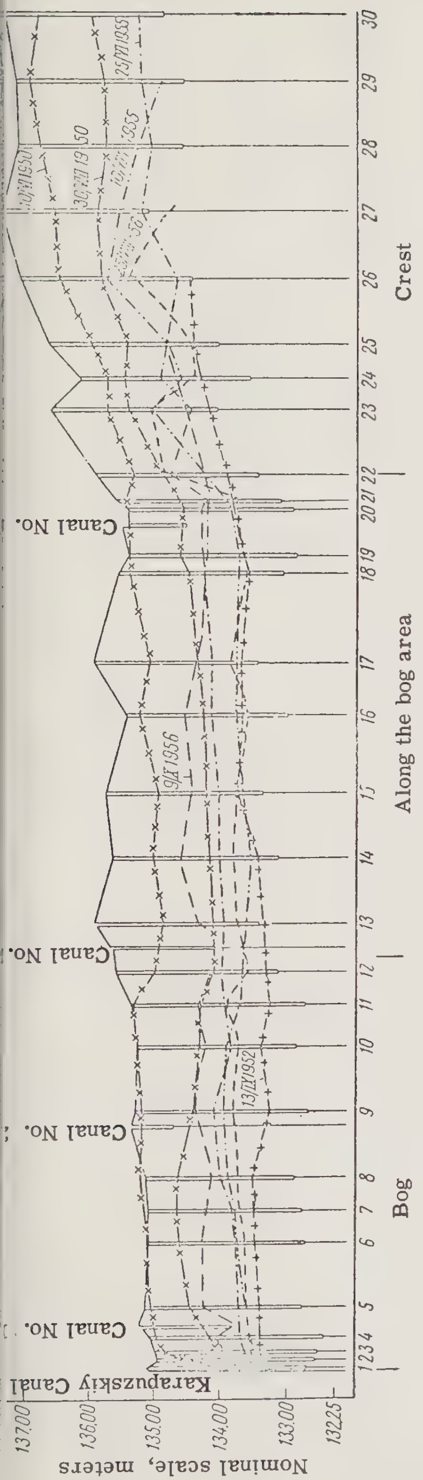

Fig. 1. - Regime of ground waters from Profile No. 1 after drainage for 1950, 1952, 1955-56

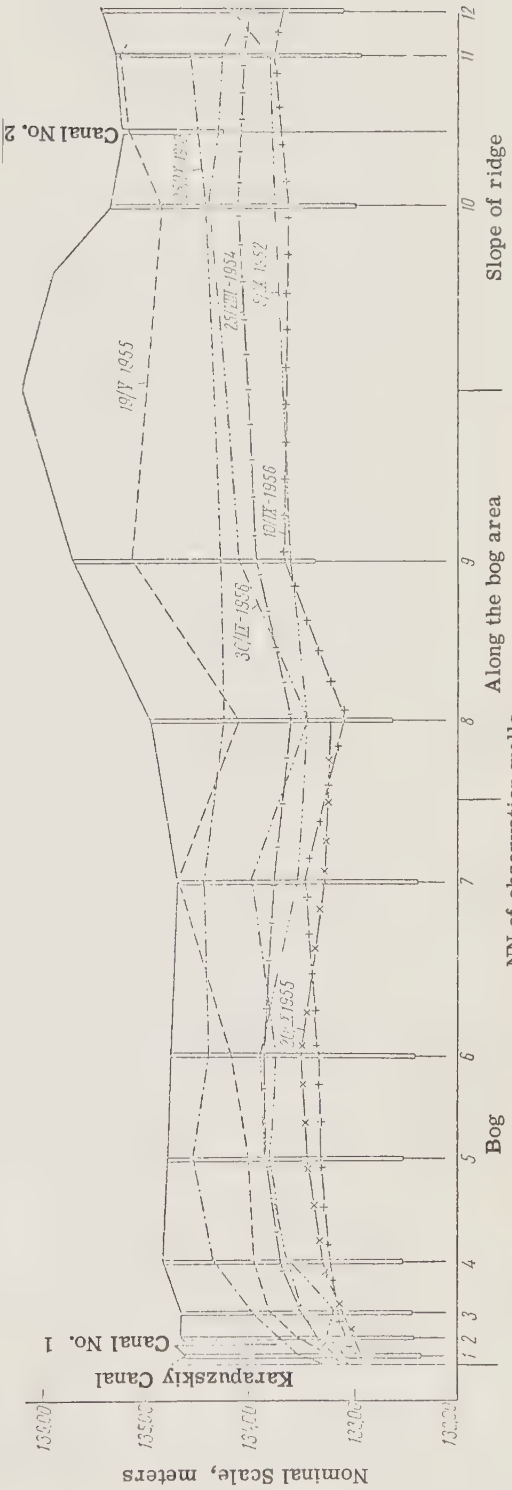

Fig. 2. - Regime of ground waters from Profile No. 2 after drainage and reclamation for 1950, 1952, 1954, 1956.

Table 3

Salt Regime of soil on bog with reference to drainage. Line 1

Year	0-20 cm layer								20-40 cm layer							
	Solid residue, %		In % and meq						Solid residue, %		In % and meq					
	Dry	Ignited	HCO$_3$	Cl	SO$_4$	Ca	Mg	Na by difference	Dry	Ignited	HCO$_3$	Cl	SO$_4$	Ca	Mg	Na by difference
Observation Well No. 2. Distance from canal, 11 m; peat thickness 150 cm																
1950	1.00	0.60	0.2544[a] 4.17[a]	0.1396 3.93	0.0082 0.17	Not determined			0.76	0.52	0.1908 3.13	0.1396 3.98	0.2507 5.22	Not determined		
1952	1.45	0.82	0.1434 2.35	0.1216 3.43	0.5261 10.96	0.0149 0.74	0.0299 2,46	0.3114 13.54	0.74	0.38	0.1075 1.76	0.0868 2,44	0.3228 6.72	0.0198 0.99	0.0299 2.46	0.1718 7.47
1956	1.70	0.97	0.0976 1.60	0.0841 2.37	0.7233 15.07	0.1484 7.41	0,1029 8,41	0.0740 3.22	1.46	0.87	0.0488 0.80	0.0919 2.59	0.6254 13.03	0.1198 5.98	0.0909 7.48	0.0680 2.96
Observation Well No. 5. Distance from canal, 101 m; peat thickness 150 cm																
1950	0.76	0.51	0.1526 2.5	0.1745 4.91	0.0254 0.53	Not determined			0.81	0.50	0.0763 1.25	0.1745 4.91	0.2630 5.48	Not determined		
1952	1.03	0.63	0.1434 2.35	0.1042 2.93	0.4151 8.65	0.0248 1.24	0,0359 2,95	0.2240 9.74	0.93	0.52	0.0956 1.57	0.1216 3.43	0.2918 6.08	0,0248 1.24		
1956	1.34	0.64	0.0573 0,94	0.0873 2.46	0.3417 7.12	0.0589 2.94	0,0670 5,51	0,0476 5.07	1.25	0.67	0.3147 5.16	0.1306 3.68	0.4152 8.65	0.0984 4.94	0.0833 6.85	0.1311 5.70
Observation Well No. 10. Distance from canal, 105 m; peat thickness 72 cm																
1950	0.95	0.59	0.1908 3.13	0.1745 4.91	0.3452 7.19	Not determined			1.13	0.87	0.0890 1.46	0.1396 3,93	0.6329 13.18	Not determined		
1952	2.11	1.44	0,0936 1.37	0.1390 3.92	1.0768 22.43	0.0198 0.99	0,0599 4,93	0.5014 21.80	1.99	1.37	0.0478 0.78	0.1216 3.43	1.0398 21.66	0.0198 0.99	0.0478 3.94	0.4816 20.94
1956	3.37	2.08	0.0488 0,80	0.2098 5.91	1.9790 41.23	0.1214 6.06	0,1647 13,55	0.6515 28.33	2,86	1.77	0.0244 0.40	0.1246 3.51	1.5969 33.27	0.0852 4.25	0.1420 11.68	0.4887 21.25

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[a] Numerator is %; denominator is meq.

Table 4

Salt regime of soil along the bog area with reference to drainage. Line 1

Year	0-20 cm layer									20-40 cm layer							
	Solid residue, %		In % and meq							Solid residue, %		In % and meq					
	Dry	Ignited	Normal carbonates	HCO_3	Cl	CO_4	Ca	Mg	Na by difference	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference
Observation Well No. 13. Distance from canal 696 m; mineral soil.																	
1950	3.26	2.89	not det.	$\frac{0.0600}{0.98}$[a]	$\frac{0.2792}{7.86}$	$\frac{1.6127}{33.60}$	$\frac{0.2472}{12.33}$	$\frac{0.2208}{18.16}$	$\frac{0.2733}{11.95}$	2.31	2.05	$\frac{0.0384}{0.63}$	$\frac{0.1396}{3.93}$	$\frac{1.3337}{27.77}$	$\frac{0.2753}{13.74}$	$\frac{0.1506}{12.39}$	$\frac{0.2026}{6.20}$
1952	5.79	5.01	0.0023	$\frac{0.0549}{0.90}$	$\frac{0.6046}{17.03}$	$\frac{3.0159}{62.83}$	$\frac{0.0059}{0.29}$	$\frac{0.0749}{6.16}$	$\frac{1.7091}{74.31}$	3.40	2.88	$\frac{0.0239}{0.39}$	$\frac{0.3197}{9.01}$	$\frac{1.8297}{38.12}$	$\frac{0.0049}{0.25}$	$\frac{0.0619}{5.09}$	$\frac{0.9701}{42.18}$
1956	4.13	3.62	not det.	$\frac{0.0799}{1.31}$	$\frac{0.4721}{13.30}$	$\frac{2.0952}{43.65}$	$\frac{0.1941}{9.69}$	$\frac{0.1887}{15.52}$	$\frac{0.7601}{33.05}$	3.83	3.62	$\frac{0.0317}{0.52}$	$\frac{0.4828}{13.60}$	$\frac{2.1148}{44.06}$	$\frac{0.2170}{10.83}$	$\frac{0.1931}{15.88}$	$\frac{0.7238}{31.47}$
Observation Well No. 17. Distance from canal 1,096 m; mineral soil.																	
1950	4.25	3.88	"	$\frac{0.0552}{0.9}$	$\frac{0.6212}{17.50}$	$\frac{2.0862}{43.46}$	$\frac{0.2773}{13.84}$	$\frac{0.3187}{26.21}$	$\frac{0.5016}{21.81}$	2.88	2.61	$\frac{0.0288}{0.47}$	$\frac{0.3350}{9.44}$	$\frac{2.2637}{47.19}$	$\frac{0.2874}{14.34}$	$\frac{0.1882}{15.48}$	$\frac{0.6264}{27.28}$
1952	4.39	4.36	"	$\frac{0.0765}{1.25}$	$\frac{0.4100}{11.55}$	$\frac{2.2345}{46.55}$	$\frac{0.0069}{0.35}$	$\frac{0.0547}{4.50}$	$\frac{1.2535}{54.50}$	3.34	2.92	$\frac{0.0355}{0.55}$	$\frac{0.4031}{11.35}$	$\frac{1.7073}{35.57}$	$\frac{0.0079}{0.39}$	$\frac{0.0642}{5.82}$	$\frac{0.9614}{41.30}$
1956	4.57	3.69	"	$\frac{0.0555}{0.91}$	$\frac{0.5899}{16.59}$	$\frac{2.1196}{44.16}$	$\frac{0.2284}{11.40}$	$\frac{0.2250}{18.51}$	$\frac{0.7302}{31.75}$	3.91	3.24	$\frac{0.0329}{0\ 54}$	$\frac{0.5101}{14.37}$	$\frac{1.8052}{37.61}$	$\frac{0.2436}{12,16}$	$\frac{0.1909}{15.70}$	$\frac{0.5671}{24\ 66}$

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[a] Numerator is %; denominator is meq.

Table 5

Salt regime of soil on elevated elements of the relief with reference to drainage. Line 1.

Year	0-20 cm layer								20-40 cm layer							
	Solid residue, %		In percent and meq						Solid residue, %		In percent and meq					
	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference
Observation Well No. 20. Distance from canal 1,261 m; peat thickness 25-30 cm (cirque).																
1950	0.38	0.25	0.0936[a] / 1.53[a]	0.0418 / 1.17	0.1693 / 3.58	0.0703 / 3.51	Not determined		0.23	0.18	0.0528 / 0.86	0.0279 / 0.78	0.0756 / 1.57	0.0542 / 2.70	Not determined	
1952	0.49	0.39	0.0451 / 0.74	0.0347 / 0.98	0.2539 / 5.33	0.0069 / 0.35	0.0226 / 1.86	0.1113 / 4.84	0.24	0.20	0.0473 / 0.78	0.0104 / 0.92	0.1011 / 2.11	0.0049 / 0.25	0.0058 / 0.48	0.0563 / 2.45
1956	0.64	0.31	0.1817 / 2.98	0.0057 / 0.16	0.0821 / 1.71	0.0381 / 1.90	0.0340 / 2.80	0.0034 / 0.15	0.23	0.14	0.0311 / 0.51	0.0184 / 0.52	0.0787 / 1.64	0.0114 / 0.57	0.0089 / 0.74	0.0312 / 1.36
Observation Well No. 23. Distance from canal, 1,411 m; mineral soil.																
1950	0.48	0.29	0.0120 / 0.20	0.0418 / 1.17	0.0641 / 1.33	Not determined			0.53	0.38	0.0240 / 0.40	0.0418 / 1.17	0.0476 / 0.99	Not determined		
1952	0.32	0.20	0.1482 / 2.43	0.0208 / 0.58	0.0472 / 0.98	0.0019 / 0.09	0.0071 / 0.58	0.0763 / 3.32	0.42	0.29	0.1553 / 2.55	0.0139 / 0.39	0.1291 / 2.69	0.0059 / 0.29	0.0167 / 1.37	0.0913 / 3.97
1956	0.31	0.16	0.0994 / 1.63	0.0269 / 0.76	0.0067 / 0.14	0.0056 / 0.28	0.0113 / 0.94	0.0303 / 1.32	0.45	0.22	0.1939 / 3.18	0.0099 / 0.28	0.0604 / 1.26	0.0188 / 0.94	0.0158 / 1.30	0.0570 / 2.48
Observation Well No. 24. Distance from canal, 1,461 m; mineral soil.																
1950	0.20	0.13	0.1128 / 1.85	0.0209 / 0.59	0.0230 / 0.48	Not determined			0.09	0.07	0.0672 / 1.10	0.0279 / 0.78	0.0533 / 1.11	Not determined		
1952	0.25	0.17	0.0932 / 1.52	0.0104 / 0.29	0.0493 / 1.02	0.0272 / 1.35	0.0083 / 0.68	0.0184 / 0.80	0.12	0.10	0.0526 / 0.86	0.0139 / 0.39	0.02460 / 0.51	not det	0.0071 / 0.58	not det.
1956	0.16	0.09	0.0683 / 1.12	0.0085 / 0.24	0.0077 / 0.16	0.0068 / 0.34	0.0036 / 0.71	0.0108 / 0.47	0.18	0.13	0.0542 / 0.89	0.0081 / 0.23	0.0806 / 1.08	0.0068 / 0.34	0.0089 / 0.74	0.0395 / 1.72

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[a] Numerator is %; denominator is meq.

Year	0-20 cm layer								20-40 cm layer							
	Solid residue, %		In percent and meq						Solid residue, %		In percent and meq					
	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference
Observation Well No. 29. Distance from canal 1,916 m; mineral soil																
1950	0.10	0.08	0.0355 0.55	0.0279 0.78	0.0287 0.59	Not determined			0,10	0,05	0,0216 0,35	0,0279 0,78	0,0164 0,34	Not determined		
1952	0.17	0.07	0.0311 0.51	0.0347 0.98	0.0287 0.59	0.0806 1.52	0.0083 0.68	not det.	0,34	0,30	0,0287 0,47	0,0104 0,29	0,2055 4,28	0,0752 3,75	0,0190 1,56	not det.
1956	0.10	0.03	0.0097 0.16	0.0298 0.84	0.0067 0.14	0.0056 0.28	0.0045 0.37	0.0113 0.49	0,11	0,07	0,0189 0,31	0,0341 0,96	0,0163 0,34	0,0056 0,28	0,0056 0,46	0,0200 0,87

is an increase of chlorides; the percentage of bicarbonates decreases; in the 20-40 cm layer of soil the percentage of bicarbonates and chlorides decreases, and the content of sulfates, Ca, Mg and Na increases. Along the bog area (Wells 8, 9) we record a decrease of bicarbonates and an increase of sulfates and chlorides. On the slope (Wells 10, 12) desalinization occurs in the upper soil layers with a certain fluctuation by years.

We must note that on the drained bog we did not observe any damage to cultivated agricultural crops during the whole time the salt regime of the soils was being studied, which probably is explained by the adequate amount of the soil of pure water from the permafrost; we also did not observe any expansion of salinized land area after drainage, as Khainskiy (16) had pointed out earlier.

Conclusions

1. Under Central Baraba conditions after drainage, degree of salinization of the plowed and subplowed layers of bog and mineral soils of the bog zone increases, chiefly owing to sulfates and, in several cases, chlorides of Ca, Mg and Na with a decrease in the quality of bicarbonates, which is expressed particularly sharply during dry years. We did not note any change in the salt regime on elevated elements of the relief after draining the bogs.

2. One of the principal factors of salt dynamics in the upper layers of soil is the soil's water regime, caused by precipitation. In this regard, in order to control soil salinization under Baraba conditions we must attach great importance to regulating the water regime of soil on all the elements of the relief by snow retention, accumulating runoff on the elevated elements of the relief and on slopes, and by carrying out other measures aimed at intensifying the downward flow in the soil (sub-soiling and mole drainage). The creation of forest strips by using natural breaks will aid in regulating surface runoff waters and increasing total air moisture. Correct use of reclaimed salinized peat-bog soils by high scientific agricultural standards of crops will enable us to prevent secondary salinization.

3. With regard to the development of drainage improvement measures on the Baraba lowland and with regard to drawing into the economic cycle the salinized bog areas, reclaimed to various degrees, there arises the need to conduct studies on the evolution of reclaimable lands in lowland districts where natural conditions differ. The migration of salts both in the upper layers of the soil and in the layers which lie under peat bog should also be studied; we should also explain the source of salt entry

Table 6

Salt regime of soil on bog with reference to drainage and reclamation. Line II.

Year	0-20 cm layer								20-40 cm layer							
	Solid residue, %		In % and meq						Solid residue, %		In % and meq					
	Dry	Ignited	HCO_3	Cl	SO	Ca	Mg	Na by difference	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference
Observation Well No. 3. Distance from canal 50 m; peat thickness 165 cm.																
1950	0.84	0.55	0.1526[a]/2.50[a]	0.2094/5.90	0.1972/4.11	Not determined			1.11	0.86	0.1653/3.71	0.1745/4.91	0.3657/7.62	0.2713/13.54	Not determined	
1952	1.49	0.88	0.1814/2.15	0.0868/2.44	0.4932/10.27	0.1888/9.42	0.0652/5.41	0.0007/0.03	1.04	0.78	0.1075/1.76	0.0695/1.96	0.4110/8.56	0.1684/8.42	0.0539/4.43	not det.
1954	1.69	1.02	0.156/2.56	0.082/2.31	0.625/13.00	not det.	0.151/12.41	not det.	1.18	0.45	0.144/2.36	0.075/2.12	0.329/0.84	not det.	0.117/9.62	none
1955	2.21	1.36	0.0730/1.20	0.1131/3.18	1.0795/22.49	0.2115/10.55	0.1328/10.92	0.1242/5.40	0.95	0.56	0.0549/0.90	0.0469/1.32	0.3000/6.25	0.1010/5.04	0.0496/4.08	not det.
1956	3.20	2.40	0.0427/0.70	0.1153/3,26	1.7111/35.64	0.2665/13.30	0.1819/14.96	0.2508/11.34	1.80	1.06	0.0268/0.44	0.0855/2.41	0.8798/18.33	0.1236/6.17	0.0965/7.94	0,1626/7.07
Observation Well No. 5. Distance from canal 200 m; peat thickness 160 cm.																
1950	0.80	0.46	0.2035/3.34	0.1745/4.91	0.2260/4.71	Not determined			0.88	0.21	0.1526/2.50	0.2096/5.90	0.2055/4.28	Not determined		
1952	1.92	1.31	0.2748/4.50	0.1737/4.89	0.5754/11.95	0.2236/11.15	0.0776/6.39	0.0881/3.83	1.31	0.93	0.1553/2.54	0.1390/3.92	0.5348/11 13	0.2236/11.15	0.0778/6.39	0.0011/0.05
1954	3.65	2.61	0.145/2.38	0.043/1.21	1.677/34.88	not det.	0.242/19.89	not det.	1.60	—	0.113/1.85	0.103/2.90	Not determined		0.121/9.55	none
1955	3.89	2.60	0.0730/1.20	0.2028/5.71	2.0676/43,08	0.3705/18.48	0.2407/19.80	0.2693/11.71	0.94	0.53	0.0427/0.70	0.0683/1.92	0.3048/6.35	0.0856/4.27	0.0508/4.18	0.0119/0.52
1956	3.38	2.45	0.0646/1.06	0.1899/5.32	1.6372/34.11	0.2759/13.77	0.1819/14.96	0.2704/11.76	2.38	1.38	0.0490/0.82	0.1494/4.21	1.1337/23.62	0.1655/8.26	0.1079/8.88	0.2647/11.51

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[a] Numerator is %; denominator is meq.

Table 6 continued

Year	0-20 cm layer								20-40 cm layer							
	Solid residue, %		In % and meq						Solid residue, %		In % and meq					
	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference
Observation Well No. 7. Distance from canal 470 m; peat thickness 90 cm.																
1950	0.83	0.56	$\frac{0.2035}{3.34}$	$\frac{0.2096}{5.90}$	$\frac{0.2466}{5.14}$	Not determined			0.69	0.49	$\frac{0.1017}{1.67}$	$\frac{0.2443}{6.88}$	$\frac{0.2712}{5.65}$	Not determined		
1954	1.07	0.45	$\frac{0.106}{1.74}$	$\frac{0.071}{2.00}$	$\frac{0.238}{5.00}$	not det.	$\frac{0.085}{6.99}$	not det.	0.89	0.37	none	$\frac{0.100}{2.82}$	$\frac{0.345}{7.18}$	"	"	
1955	3.45	2.45	$\frac{0.0730}{1.20}$	$\frac{0.1195}{3.36}$	$\frac{2.0525}{42.76}$	$\frac{0.3466}{17.29}$	$\frac{0.2090}{17.19}$	$\frac{0.2953}{12.84}$	1.22	0.82	$\frac{0.0305}{0.57}$	$\frac{0.0170}{0.48}$	$\frac{0.5794}{12.07}$	$\frac{0.1219}{6.08}$	$\frac{0.0831}{6.84}$	$\frac{0.0046}{0.20}$
1956	2.71	1.62	$\frac{0.0646}{1.06}$	$\frac{0.3205}{9.03}$	$\frac{1.7771}{24.94}$	$\frac{0.2094}{10.45}$	$\frac{0.1477}{12.15}$	$\frac{0.2859}{12.43}$	1.88	1.26	$\frac{0.0183}{0.30}$	$\frac{0.0213}{0.60}$	$\frac{0.9777}{20.37}$	$\frac{0.1579}{7.88}$	$\frac{0.1045}{8.60}$	$\frac{0.1101}{4.79}$

Table 7

Salt regime of soil on bog with reference to drainage and reclamation. Line II.

Year	0-20 cm layer								20-40 cm layer							
	Solid residue %		In % and meq						Solid residue %		In % and meq					
	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference
Observation Well No. 8. Distance from canal 628 m; mineral soil.																
1950	0.96	0.57	$\frac{0.1560}{2.56}$[a]	$\frac{0.1047}{2.95}$	$\frac{0.1890}{3.94}$	$\frac{0.0764}{3.81}$	$\frac{0.0753}{6.19}$	None	0.35	0.27	$\frac{0.0456}{0.74}$	$\frac{0.0628}{1.77}$	$\frac{0.0608}{1.26}$	$\frac{0.0522}{2.60}$	Not determined	
1954	1.71	0.78	$\frac{0.228}{3.74}$	$\frac{0.114}{3.21}$	$\frac{0.518}{10.77}$	not det.	$\frac{0.136}{11.18}$	not det.	0.99	0.43	$\frac{0.183}{3.00}$	$\frac{0.075}{2.12}$	$\frac{0.132}{2.75}$	Not determined		
1955	1.93	1.40	$\frac{0.1000}{1.64}$	$\frac{0.1622}{4.57}$	$\frac{1.0498}{21.87}$	$\frac{0.1338}{6.65}$	$\frac{0.1212}{9.97}$	$\frac{0.2636}{11.46}$	0.48	0.32	$\frac{0.0293}{0.47}$	$\frac{0.0352}{0.99}$	$\frac{0.2280}{4.75}$	$\frac{0.0276}{1.38}$	$\frac{0.0162}{1.33}$	$\frac{0.0805}{3.50}$
1956	3.20	2.04	$\frac{0.0976}{1.60}$	$\frac{0.2101}{5.92}$	$\frac{1.4659}{30.54}$	$\frac{0.1523}{7.60}$	$\frac{0.1534}{12.62}$	$\frac{0.4103}{17.84}$	0.91	0.65	$\frac{0.0202}{0.33}$	$\frac{0.0866}{2.44}$	$\frac{0.4516}{9.41}$	$\frac{0.0424}{2.12}$	$\frac{0.0408}{3.36}$	$\frac{0.1541}{6.70}$
Observation Well No. 9. Distance from canal 783 m; mineral soil.																
1950	1.42	1.12	$\frac{0.1032}{1.69}$	$\frac{0.2164}{6.09}$	$\frac{0.5754}{11.98}$	$\frac{0.0945}{4.71}$	$\frac{0.1004}{8.26}$	$\frac{0.1562}{6.79}$	1.49	0.72	$\frac{0.0576}{0.94}$	$\frac{0.1396}{3.93}$	$\frac{0.4110}{8.57}$	$\frac{0.0985}{4.91}$	$\frac{0.0903}{7.43}$	$\frac{0.0253}{1.10}$
1954	1.59	1.12	$\frac{0.108}{1.77}$	$\frac{0.263}{7.42}$	$\frac{0.650}{13.52}$	$\frac{0.128}{6.38}$	$\frac{0.059}{4.85}$	$\frac{0.2640}{11.48}$	1.55	not det.	$\frac{0.049}{0.80}$	$\frac{0.220}{6.20}$	$\frac{1.031}{21.44}$	$\frac{0.212}{10.58}$	$\frac{0.084}{6.90}$	$\frac{0.2521}{10.96}$
1955	2.21	1.51	$\frac{0.1159}{1.90}$	$\frac{0.3952}{11.13}$	$\frac{0.8851}{1.844}$	$\frac{0.0972}{4.85}$	$\frac{0.1351}{11.11}$	$\frac{0.3567}{15.51}$	1.17	0.78	$\frac{0.0590}{0.97}$	$\frac{0.2428}{6.82}$	$\frac{0.4646}{9.68}$	$\frac{0.0495}{2.47}$	$\frac{0.0001}{4.94}$	$\frac{0.2314}{10.06}$
1956	3.13	2.32	$\frac{0.0634}{1.04}$	$\frac{0.3557}{10.05}$	$\frac{1.5883}{33.09}$	$\frac{0.1959}{9.78}$	$\frac{0.1955}{16.08}$	$\frac{0.4213}{18.32}$	2.20	1.63	$\frac{0.0402}{0.66}$	$\frac{0.2705}{7.62}$	$\frac{1.0339}{21.54}$	$\frac{0.1637}{8.17}$	$\frac{0.1113}{9.16}$	$\frac{0.2872}{12.49}$

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[a] Numerator is %; denominator is meq.

Table 7 continued

Year	0-20 cm layer								20-40 cm layer							
	Solid residue %		In % and meq						Solid residue %		In % and meq					
	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference	Dry	Ignited	HCO_3	Cl	SO_4	Ca	Mg	Na by difference
Observation Well No. 10. Distance from canal, 1,133 m; thickness 30-40 cm (hollow).																
1950	0.85	0.21	$\frac{0.1032}{1.69}$	$\frac{0.0279}{0.76}$	$\frac{0.9338}{19.45}$	$\frac{0.2392}{11.94}$	$\frac{0.0727}{5.98}$	$\frac{0.9200}{4.0}$	0.29	0.23	$\frac{0.0672}{1.10}$	$\frac{0.0349}{0.98}$	$\frac{0.0953}{1.98}$	$\frac{0.0462}{2.30}$	Not determined	
1954	0.44	0.29	$\frac{0.149}{2.44}$	$\frac{0.036}{1.02}$	$\frac{0.201}{4.18}$	$\frac{0.042}{2.10}$	$\frac{0.027}{2.22}$	$\frac{0.0764}{3.32}$	0.22	0.11	$\frac{0.080}{1.31}$	$\frac{0.0140}{0.40}$	$\frac{0.072}{1.50}$	$\frac{0.028}{1.40}$	$\frac{0.022}{1.81}$	Not det.
1955	0.31	0.22	$\frac{0.0646}{1.06}$	$\frac{0.0029}{0.08}$	$\frac{0.0250}{0.52}$	$\frac{0.0146}{0.73}$	$\frac{0.0096}{0.79}$	$\frac{0.0032}{0.14}$	0.23	0.11	$\frac{0.0378}{0.62}$	$\frac{0.0042}{0.12}$	$\frac{0.0086}{0.18}$	$\frac{0.0038}{0.19}$	$\frac{0.0036}{0.30}$	$\frac{0.0099}{0.43}$
1956	0.34	0.61	$\frac{0.1256}{2.06}$	$\frac{0.1088}{3.01}$	$\frac{0.0633}{1.32}$	$\frac{0.0398}{1.99}$	$\frac{0.0499}{4.11}$	$\frac{0.0064}{0.28}$	0.27	0.13	$\frac{0.0439}{0.72}$	$\frac{0.0014}{0.04}$	$\frac{0.0049}{0.10}$	$\frac{0.0022}{0.11}$	$\frac{0.0059}{0.49}$	$\frac{0.0059}{0.26}$
Observation Well No. 12. Distance from canal 1,336 m; mineral soil.																
1950	2.15	1.90	$\frac{0.0528}{0.86}$	$\frac{0.0279}{0.78}$	$\frac{1.0850}{22.61}$	$\frac{0.1949}{9.72}$	$\frac{0.0778}{6.40}$	$\frac{0.1869}{6.13}$	0.77	0.36	$\frac{0.2035}{3.34}$	$\frac{0.2096}{5.90}$	$\frac{0.2466}{5.14}$	$\frac{0.0603}{3.01}$	$\frac{0.0652}{5.36}$	$\frac{0.1382}{6.01}$
1954	0.91	0.80	$\frac{0.312}{5.12}$	$\frac{0.037}{1.04}$	$\frac{0.326}{6.78}$	$\frac{0.0216}{1.18}$	$\frac{0.022}{1.81}$	$\frac{0.2288}{9.95}$	0.68	0.52	$\frac{0.236}{3.87}$	$\frac{0.022}{0.62}$	$\frac{0.284}{5.91}$	$\frac{0.024}{1.20}$	$\frac{0.029}{2.30}$	$\frac{0.1587}{6.90}$
1955	0.33	0.16	$\frac{0.1671}{2.71}$	$\frac{0.0051}{0.14}$	$\frac{0.0067}{0.14}$	$\frac{0.0022}{0.11}$	$\frac{0.0074}{0.61}$	$\frac{0.0522}{2.27}$	1.24	0.15	$\frac{0.1331}{2.28}$	$\frac{0.0029}{0.08}$	$\frac{0.0067}{0.14}$	$\frac{0.0026}{0.14}$	$\frac{0.0029}{0.24}$	$\frac{0.0492}{2.14}$
1956	0.40	0.15	$\frac{0.2257}{3.70}$	$\frac{0.0028}{0.08}$	$\frac{0.0038}{0.08}$	$\frac{0.0006}{0.03}$	$\frac{0.0170}{1.40}$	$\frac{0.0558}{2.43}$	0.28	0.10	$\frac{0.2128}{3.49}$	$\frac{0.0035}{1.10}$	$\frac{0.0240}{0.5}$	$\frac{0.0018}{0.09}$	$\frac{0.0044}{0.37}$	$\frac{0.0854}{3.63}$

into the upper layers of soil, in order to concentrate on controlling salinization and preventing secondary salinization.

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HE ROLE OF YEASTS OF THE GENUS LIPOMYCES N SOIL PROCESSES

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At the present time there is a broad litera- re devoted to yeasts. Because yeasts carry n many fermentation processes and have ng been put to practical use, they were udied early and thoroughly to improve manu- cturing processes. Far less attention was ven to the distribution of yeasts in nature, d relatively little work has been done on the ccurrence of yeasts in the soil. Starkey and enrici (12), in treating this question, ob- rved that yeasts are relatively infrequent soils. They were of the opinion that these ganisms merely survive there, and that they n have no significant effect on the conversion substances in the soil or in changing the soil ructure, pH, or other factors.

Starkey (11) later described a group of asts, consistently isolated from the soil on trient media, that contained no nitrogen mpounds. He even assigned this group to e ordinary soil population. These yeasts ore considerable quantities of fat internally, d on the basis of this characteristic Lodder d Kreger (8) assigned them to the genus pomyces. Lund (9) described methods to cilitate the counting of yeasts in soil. Using ese methods he found a considerable quantity yeasts in the soil, but lipomycetes were ob- rved in smaller numbers than were other rms.

In the Soviet Union, the distribution of pomycetes in the soils of Yakutiya is de- ribed by Mazilkin (4). These data are new d interesting, but do not reveal any features aracterizing the distribution of lipomycetes in fferent soil groups.

Over a period of 4 years we analyzed 60 mples of virgin and cultivated soils from fferent geographic zones. A definite weighed rtion of soil (0.1-0.2 g) was inoculated in a tri dish containing Ashby's nitrogen-free ar medium (K_2HPO_4), 0.02%; $MgSO_4$, 0.02%; Cl, 0.02%; K_2SO_4, 0.01%; mannite, 1.5%; chalk, 3%; agar-agar, 2%; and distilled water). After -16 days of incubation at 26° -28°C, we counted the lumps of soil overgrown with yeast colonies and computed their percentage. Yeasts belonging to the genus Lipomyces were observed in 31 different soil samples; the percentage of soil lumps overgrown with these microorganisms varied (Table 1). From the results of inoculation with such a small number of samples it is not yet possible to demonstrate any regular pattern in the distribution of lipomycetes in different soils, especially since many of the samples were cultured only once from old air-dried specimens. In any event, the smallest numbers of lipomycetes were observed in samples from northern and central Asia. In the remaining samples they were encountered in varying numbers from different soil environments.

We isolated a series of pure cultures of these microorganisms and studied their morphological, cultural, and biochemical characteristics.

Morphologically, they are either round or bluntly oval cells, individual or with a single bud. A large drop of fat is located inside the cell, and a thick slime capsule surrounds it. This slime capsule varies greatly in thickness and often exceeds the diameter of the cell by several times (Figs. 1, 2). Because of the ability of lipomycete cells to form large amounts of slime, cultures on agar media have a mucoid consistency and flow downwards. Cultures grown in liquid media cause a general sliming of the latter.

Thus, the microorganisms studied are characterized not only by the formation of fat inside the cells, but by the formation of a still greater quantity of slime, which is secreted into the outside medium. Lipomycetes multiply by budding and by spore formation. We observed the process of sporogenesis when cultivating these yeasts on a starvation medium (water agar). The spores are formed in asci with 1-15 spores in each (Fig. 3). A more detailed description of the morphological and cultural characteristics of these lipomycetes

Table 1

Lipomycete content in soils

Region and site where samples were taken	Soil	Land type	% of soil lumps covered with lipomycetes
Komi ASSR, Syktyvkar, Troitsko-Pechorsk	Gleyed-strongly podzolic	Potato field	None
		Spruce forest 2 samples	None
Komi ASSR, Syktyvkar	Sod-gleyed	Plowed land	Very small
Komi ASSR, central port. of Pechora river valley	Alluvial, sod-meadow	Grassy meadow with various herbage	None
Komi ASSR, channel area of Pechora river valley			None
Moscow regions, Dmitrov district, State Type Trace No. 93	Sod-podzolic	Forest	5-7
		Plowed land, 2 samples from land in different crops	5-7
Moscow region, Dmitrov district	Peat-humus, ferrous on sedge-forest peat	Perennial grasses	to 100
		Fallow	to 30
	Peat humus, ferrous carbonate on sedge-Hypnum peat	Perennial grasses	to 5
		Fallow	None
	Peat humus	Raised virgin soil	11
Moscow region, Serpukhov district, "Bol'shevik" sovkhoz	Floodplain soil from Oka river	Meadow	36
		Plowed land	14-36
Novosibirsk region, Ubinskiy district, Experimental Melioration Station (UOMS)	Peat bog, cultivated 10 years	Fallow	10
		Perennial grasses	95
	Peat bog	Drained virgin soil, 0-10 cm deep	2.5
		Drained virgin soil, 15-25 cm deep	None
Tula Forest Preserve	Gray forest	Forest	44
		Plowed land	6
Kursk region, Streletskaya steppe	Thick chernozem	Virgin steppe	25
		Plowed land	27
Kursk region	Th[illegible]ernozem	Plowed land	to 2.5
Western Siberia, Shadrinsk	Fertile and leached chernozem	Plowed land	Nearly 1
Stalingrad region, Lemeshkin district	Ordinary chernozem	Forest planted about 50 years	to 25
		Steppe-waste-land	25 or more

Table 1 (continued)

Region and site where samples were taken	Soil	Land type	% of soil lumps covered with lipomycetes
Stalingrad region, Vyazovskiy district, "Belye Prudy" sovkhoz	Southern chernozem	Forest planted about 50 years	5-10
		Steppe-wasteland	5-10
Buryat Mongolia, Transbaykal steppes	Chernozem	Steppe and virg. soil	None
Same	Dark chestnut, 2 samples	Steppe and virgin soil	10
			None
Buryat Mongolia, Bargyzenski basin	Dark chestnut, 2 samples	Same	None
Western Kazakhstan, Dzhanybek	Dark-colored	3-year fallow	20
Western Kazakhstan, Dzhanybek	Solonchak solonetz	Virgin soil	None
		Plowed land	None
		Test with an admixture of plant residues	High
Western Kazakhstan, Land Shala-Kupa	Solonchak	Virgin soil under saltwort and sedge	None
Samarkand oasis, Kata Kurgan	Ordinary sierozem	Virgin soil	None
		Long irrigated	None
Samrakand oasis, Ziadin	Light sierozem	Virgin soil	None
		Irrigated	None
Bukhara oasis	Desert sierozem	Virgin soil	None
	Sierozem-meadow	Long irrigated	None
	Saline sierozem-meadow	Long irrigated	None
	Marshy solonchak, 2 samples	Virgin soil	None
Bukhara oasis, Khadzhiyap	Solonchak, 2 samples	Virgin soil	None
Barabinsk lowland	Sodium solonchak	Virgin soil	None
Western Turkmenia	Takyrs	Film of algae	None
Northern Ossetia	Leached Ciscaucasus chernozem	Plowed land	High
Krasnodar subdistrict, Goryzcheklyuchevskiy district	Dark gray	Corn field	100
		Forest	10
Krasnodar subdistrict, Apsheronskiy district	Light gray	Plowed land	30
		Forest	None

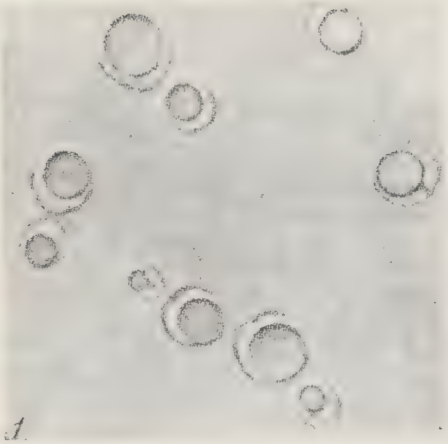

Fig. 1. - Lipomycete cells on Ashby's agar.

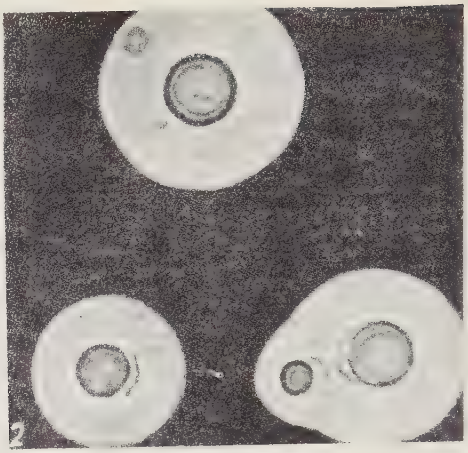

Fig. 2. - Slime capsule around cells. Stained preparation.

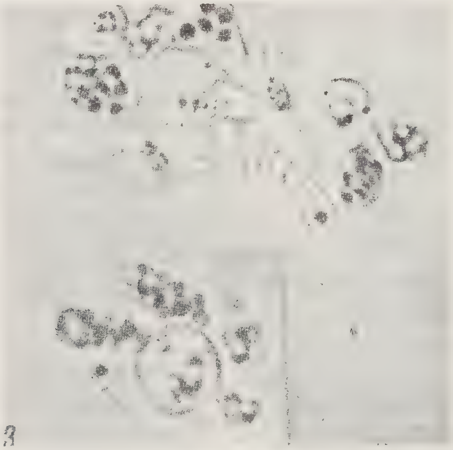

Fig. 3. - Spores in sacs.

is given in our previous work (2).

In our study of the biochemical characteristics of the lipomycetes on synthetic nutrient media, the growth and accumulation of a mass of cells was very slow, as was the accumulation of the metabolic products of the cells. This not only hampers our study of the physiological characteristics of the organisms but may very well distort our ideas about them. The addition of some sort of natural substrate might have stimulated their growth. The humic substances in soil are such a substrate for soil microorganisms. Kudrina (3), on the basis of broad data, demonstrated the effect of humic acid on a number of soil microorganisms. This stimulates multiplication in many of these and increases the biochemical activity of the cells. Similar results were obtained by Rybalkina (7) with Clostridium pasteurianum. An experiment was conducted with Ashby's liquid medium to verify the effect of humic acid on a pure culture of lipomycetes. According to existing data, the growth of lipomycetes in Ashby's liquid medium with mannite is not as good as it is with glucose. After 40 days of growth, strain No. 76 produced 10.8 x 10^6 cells in 1 ml of nutrient medium with mannite, and 27 x 10^6 cells with glucose. We therefore replaced the mannite in Ashby's medium to 2% glucose.

The experiment was carried out in wide-bottomed flasks with a capacity of 1,750 ml. We poured 100 ml of medium into the flasks, forming a layer of almost 2 cm. After staining the medium to a brownish-yellow color, we inserted 0.05 g of partially dissolved dry umic acid (Merck) into half of the flasks. trains No. 60 and 70 of the lipomycetes were sed for the inoculation. One ml of cells uspended in water was put into each flask. ll flasks were then incubated at 26°C for 69 ays. During this period a portion of the edium evaporated and an intense sliming of e culture liquid occurred. Sliming was not bserved in the control (non-inoculated) flasks. t the end of the experiment we brought the olume of liquid in all the flasks up to its riginal level and dry chalk residue was dis-olved with a 10% solution of HCl. Attempts o separate the cells from the slimy liquid ere unsuccessful. The cells were counted wice; 34 and 69 days after inoculation. The ata obtained, presented in Table 2, demon-trated that the number of cells in a medium ith humic acid was two to three times greater han without it. Towards the 69th day the umber of cells dropped, but this drop was ess in the medium that contained the humic cid. Microscopic examination revealed that ore young cells and fewer deformed and dead ells were observed in the media with the umic acid. The humic acid added to the nu-rient medium stimulated the multiplication of e cells and slowed their aging, which, in urn, led to a large accumulation of cell ma-erial.

The data of a chemical analysis testify to e significant effect of humic acid on the bio-hemical processes in cultures of lipomycetes. he dry residue of the culture liquid is lower than that of the control nutrient medium, and is much less with humic acid. The sugar consumption is greater in the medium containing the humic acid, as is the total loss of carbon. This is evidence of the more vigorous respiratory process in the presence of humic acid, a fact fully in keeping with the morphological data pointing to the lower average age of cells in these media.

By comparing the carbon loss in the sugar consumed and the total loss of carbon in the culture, we can see that not all of the carbon is burned to form CO_2. A large portion of it remains in the culture and is apparently converted into other, more complex, compounds such as fat and slime. This process is found to be inversely related to the addition of humic acid to the nutrient medium.

We did not observe nitrogen losses in a single instance. Lipomycetes apparently cannot fix atmospheric nitrogen, but these microorganisms may be satisfied with very small amounts of nitrogen and at the same time convert hundreds of times more hydrocarbons. This is evidence that the microorganisms studied are active participants in the carbon cycle in nature.

One of the compounds formed by the lipomycetes is the slime, which they secrete into the medium. Numerous investigators (1, 5, 6, 10, 13) are of the opinion that microorganisms may have an effect on the structural

Table 2

The effect of humic acid on pure cultures of slime yeasts

Strain No.	Treatments	No. of cells /ml of culture liquid, millions		Dry residue, %	Total C content, % (Tyurin's method)	Sugar content, % (Betrand's method)	C content in sugar, % (calculated)	Amount of additional sugar required, % of initial	C loss, %		Amount of C converted by yeasts from sugar to other forms, % of C	N Content, % (Kjeldahl method)
		In 34 days	In 69 days						In required sugar	In culture liquid		
Control	Ashby's medium	—	—	1.81	0.797	1.90	0.76	—	—	—	—	0.0003
	Ashby's medium + 0.05 % humic acid	—	—	2.00	0.876	2.20	0.88	—	—	—	—	0.003
60	Ashby's medium	32	8.8	1.66	0.719	1.25	0.50	34.2	0.26	0.078	70.0	0.0004
60	Ashby's medium + 0.05% humic acid	108	42.8	1.50	0.647	0.62	0.25	71.6	0.63	0.225	63.6	0.003
70	Ashby's medium	68	16.8	1.55	0.618	0.60	0.24	68.4	0.52	0.179	65.6	0.0009
70	Ashby's medium + 0.5% humic acid	136	60	1.25	0.522	0	0	100	0.88	0.354	59.7	0.003

Content of C in compound of humic acid 50 to 55%; N content 4 to 6%.

properties of soil by forming water-stable aggregates. In Mishustin's opinion, soil aggregates formed by the action of bacterial slimes, albumins, and the binding force of fungal mycelia are less stable than aggregates formed by the action of humic substances, which microorganisms find it hard to break down.

In this experiment we attempted, only in a general sense, to investigate the ability of lipomycete slime to produce water stable aggregates.

Aggregates 3-5 mm in diameter of a cultivated sod-podzolic soil from State Experiment tract No. 93 in Dmitrov district (Moscow region) were selected for this experiment. The experiment was conducted in the following manner: The slime from pure cultures of lipomycetes was obtained by cultivating two strains for 15 days in Petri dishes containing Ashby's agar. Then the slime was removed from the surface of the agar and diluted twice with water, since it had a rather thick consistency. The dry residue of this mass amounted to 1.71%. Half of the slime was heated at 100° C for 40 minutes; this killed all living cells. The soil aggregates were saturated with the slime by capillary saturation. The bottom of a Petri dish was covered with two layers of fiberglas on which 3.5 ml of slime was uniformly applied. In this case water alone was used for the control. A single layer of thinner fiberglas was placed on the slime and 6 g of soil aggregates were spread evenly on top. Altogether, 30 dishes were prepared, with 10 dishes of each treatment. The aggregates were saturated very quickly by the water and considerably more slowly by the slime. The dishes were covered and left for two days; during this time the aggregates became completely saturated with moisture. Koch dishes with soil plates from two different soils were prepared at the same time. The latter were moistened approximately to their minimum water capacity.

The aggregates were completely removed from a portion of the dishes saturated with water and slime, together with the upper layer of fiberglas, and placed on the surface of the soil layers without disturbing the aggregates. Then the Koch dishes were covered. The aggregates remaining in the Petri dishes were dried for eight days with covers off at 23°-24°C. Then, half of the dry aggregates were also transferred to the soil plates. In this way 15 treatments, each in two replications, were set up. After 69 days the aggregates were again transferred from the soil to the Petri dishes for drying. Five months after the start of the experiment, the aggregates were analyzed for water stability by the combined method of Savvinov and Baksheyev. Five grams of aggregates were taken for each analysis.

The data presented in Table 3 indicate that lipomycete slime significantly increases the water stability of soil aggregates. The water stability of aggregates treated with the slime decreases under the action of the soil. This is especially marked if the aggregates are subjected to the action without drying, after saturation with slime. Apparently the slime changes its properties during drying and, as a result, the soil aggregates acquire a particular stability. It also follows from this experiment that the aggregates acquire water stability by the action of the slime secreted by the cells into the outside medium, and not by the action of the living cells.

Conclusions

1. Yeasts of the genus Lipomyces occur widely in the soils of the Soviet Union.

2. They are capable of growing on nutrient media containing insignificant amounts of nitrogen, but they cannot fix nitrogen.

3. The amount of carbon which the lipomycetes can assimilate from the hydrocarbons of the nutrient medium is hundreds of times greater than the amount of nitrogen. A portion of the hydrocarbons is used in respiration, while the other, larger, portion is converted into more complex compounds, such as fat and slime.

4. Addition of humic acid to the nutrient medium activates the biochemical processes in the cells. In addition, the processes of multiplication, sugar consumption, and respiration are stimulated while cell aging is retarded. The conversion of sugar to the more complex hydrocarbons — fats and slimes — is also slowed.

5. Lipomycetes can affect the structural properties of a soil, since their slime increases the water stability of the soil aggregates.

6. In view of all we have said previously, we consider yeasts of the genus Lipomyces to be typical soil microorganisms and active participants in the carbon cycle in the soil.

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Table 3

The effect of lipomycete slime on the water stability of aggregates, in percentage

Treatments			Aggregates											
			Water-saturated				Saturated with lipomycete slime				Saturated with slime of dead lipomycetes			
			Aggregate diameter, mm											
			>3	3—1	1—0.25	<0.25	>3	3—1	1—0.25	<0.25	>3	3—1	1—0.25	<0.25
Aggregates dried on fiberglas			2.8	7.7	30.9	58.6	63.8	13.7	10.3	12.2	58.9	21.7	11.2	8.2
Aggregates decomposing on soil	Sod podzolic	After preliminary drying	4.5	7.0	36.3	52.2	29.2	18.3	26.7	25.8	22.4	21.4	30.3	25.9
		Not dried	3.9	6.7	31.2	58.2	6.4	10.0	38.2	45.4	10.7	20.5	48.4	20.4
		After preliminary drying	4.9	6.6	35.0	53.5	35.9	16.2	24.9	23.0	21.9	17.7	34.2	26.2
		Not dried	2.2	4.9	34.2	58.7	4.6	11.0	43.1	41.3	4.1	12.9	39.6	43.4

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THE EVOLUTION OF SOLODS

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The genesis of solods is explained in sufficient detail in the works of numerous authors. Their further evolution, however, has received little study up until now. A few notes on this problem were made by Kolesov (3) who considers that "the sod-forming process, developing in a solod in a pure plantation and with slight marshiness, leads to the formation of a meadow-type soil, and may lead further to the development of a steppe or a bog" (p. 22). Gorshenin (2) notes that the sod-forming process in solodized soils may be manifested to varying degrees, so that we have the dark gray, gray and light gray sod-solodized soils.

To clarify the evolution of solods, it is quite useful to study the aspen scrub of Khrenovoye district in Voronezh region. T. I. Popov (5) was the first to note the penetration of oak and associated species into the aspen scrub. According to Popov, aspen-oak and oak depression scrub are the final stage in the evolution of solodized depressions. The drainage of the interfluve plays an important role in this evolution. These ideas received support in a work by F. N. Mil'kov (4). It is evident that the invasion of the tree species mentioned by Mil'kov into the aspen brush is closely related to a change in the growth conditions of the soil as well as to increased drainage of the area with a consequent drop in the water table.

We have made a study of aspen-scrub soils and attempted to explain the evolution of solods under the conditions of the southern Oka-Don lowland.

Near the town of Khrenovoye in Voronezh region, tracts of land were selected for study where aspen and aspen-elm brush is mixed with open solodized forest clearings.

The soil of the forest clearings consists of crusty carbonate solonetzes; that under the scrub consists of solods and solodized soils. Loess-like clay is the soil-forming parent material.

Field studies showed that the soil in the forest stands depended closely on the tree species present, their age, and their density. Solods have formed in dense pure aspen stands. Aspen stands with an admixture of broadleaf species are usually older, thinner, and have a well-developed grass cover. These stands have gray solodized (forest-type) soils, with less solodization as the percentage of broadleaf species increases.

Morphological field observations as well as laboratory analyses indicate that the genetic predecessors of the scrub soils were crusty carbonate solonetzes similar to those which now cover the numerous forest clearings with brush. We may assume that this change of species in the aspen stands results in the evolution of solods into gray solodized, and later into dark gray, slightly solodized (forest-type) soils. In our opinion, this assumption is supported by the data cited here.

Soils ranging from solods to dark gray, slightly solodized soils with intergradations, were observed under the aspen and mixed brush in the area investigated. Samples of the genetic horizons from four profiles located under three different forest stands and in a clearing surrounded by scrub were taken for chemical and physical-chemical analyses.

Profile 1: Located in an open clearing. The soil is a crusty carbonate solonetz-solonchak, effervescing from 10% HCl at a depth of 8 cm; thickness of the A + B_1 horizon is 10 cm.

Profile 2: Located 100 m west of the first profile in the center of a pure aspen stand; the soil is solod. Morphologically it shows a clearly defined A_2 horizon 11 cm thick and relict indications of a columnar horizon. These show that the genetic predecessor of the solod was a crusty solonetz. Over the A_2 horizon we distinguish a sod horizon 3-4 cm thick. Effervescence depth is 140 cm; the depth of the depression is 85 cm; and the ater table is 2.82 m[1] deep.

Profile 3: Located 70 m south of Profile 1 i the center of a second stand (of aspen and lm), in a portion with almost 30% stand of rees. The soil is gray, solodized, and is lso characterized by an A_2 horizon 14 cm ick that is gray with a whitish tinge. The tructure is blocky-platy with a granular adiixture. The B_1 horizon is much darker than ie A_2, shiny, and sticky; effervescence depth s 157 cm; the depression is 73 cm deep; and ie water table is 3.58 m deep.

Profile 4: Located 250 m southeast of rofile 1 in the center of a third stand. This tand is thinner with aspen (45%), elm (40%), ild Norway maple, and wild pear. There is well-developed cover of grass. The soil is ark gray, slightly solodized (forest-type). he A_2 horizon is absent, but the lower portion f the A horizon has numerous small whitish atches; the structure here is coarser and beongs to the granular-nutty type. This portion f the horizon may be distinguished as a A_2B orizon. The depth of effervescence from 10% Cl is 198 cm; the depth of the depression s 97 cm; and the water table is 4.11 m deep.

In the B horizon a luster has been retained n the faces of the blocky-prismatic units as ell as a stickiness.

When we analyze the morphological indicaors, a gradual increase in the thickness of ie humus horizon and a decrease of salinity i the B horizon become apparent as we go rom a solod to the dark gray, slightly solodzed soil. The structure changes from silty-laty in the solod to silty-granular in the A orizon of dark gray, slightly solodized soil. he signs of solodization, which are well-dened in the solod, gradually disappear in the oils of the aspen-elm scrub.

Crusty carbonate solonetzes, similar to iose found in the numerous open clearings in ie aspen scrub, apparently were the progeniors of these soils. This is supported by the resence of relict indications of solonetz in ie solod and gray solodized soils, i. e. by ie presence of a relict columnar illuvial orizon, by the identical textural profiles of all ie soils (Table 1), by the presence of adsorbed odium as one of the exchangeable cations and ie high absolute and relative magnesium conent, and by the distribution of the exchangeble cations over the profile of the soils in uestion (Table 4). All of these relict solonetz idicators have been distinctly retained in the olod, but in the gray solodized (forest-type) oils they are gradually obliterated as the sod forms. However, if we compare the whole series of soils, they can be clearly detected.

K. K. Gedroyts (1) pointed out that solodization is less vigorous in carbonate solonetzes and that the calcium in the soil solution gradually displaces the adsorbed sodium, thereby gradually transforming the adsorption complex of the solonetz from a state of partial or total sodium saturation to that of calcium saturation. In solodization the carbonate solonetzes lose chiefly the organic portion of the adsorption complex, while the mineral portion is comparatively less affected. Under these conditions it is obvious that after the solodization stage is completed in the solonetz, the adsorption complex will not be completely destroyed since sod development can restore the organic portion of the adsorption complex and this will be saturated with calcium. Our physical-chemical and chemical analyses support these assumptions.

The results of the particle-size analysis (Table 1) indicate that all the soils belong to the clayey silty-clay group. The upper portion of the solonetz profile is markedly deficient in the clay fraction while there is a relative increase here in sand and silt particles. The number of clay particles doubles in the illuvial horizon from 20-30 cm. The clay fraction of the eluvial horizon (from 20-30 cm in the solod) was further reduced during solodization, i. e. the highly dispersed minerals were composed also in the upper portion of the illuvial horizon of the former solonetz. A secondary accumulation of clay particles is noted during the evolution of the solods because of recent sod-formation in the upper 20-cm soil layer. This secondary accumulation is shown particularly well if we examine the data for particle-size analyses of a solod, a gray solodized, and a dark gray, slightly solodized soil.

The data from a water-extract analysis are presented in Table 2. These data show that a crusty solonetz-solonchak has a high content of water-soluble salts. The maximum concentration of these salts is found at a depth of 20-50 cm. The $NaHCO_3$ distinctly predominates throughout the entire profile (to 120 cm); the other salts are less important. Solodization of the solonetzes led to a marked decrease in the content of water-soluble salts. It should be noted that there is some increase of salts in the top 5-cm layer of the solod and solodized soils. This is explained by an accumulation of water-soluble substances because of mineralization of forest litter.

The amount of solid residue in the solod and solodized soils is slight and indicates their complete desalinization. Their salt composition is approximately identical. The organic portion of the soil undergoes the most substantial changes during the evolution of solods. As

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[1] The water table was determined from boring data r September 18, 1958.

Table 1

Particle-size analysis by the pipette method, percent of dry weight

Soil	Depth, cm	Solution loss, %	Particle diameter, mm							
			>0.25	0.25 – –0.05	0.05 – –0.01	0.01 – –0.005	0.005 – –0.001	<0.001	<0.01	>0 01
Crusty solonetz	0—10	1.77	2.48	27.31	29.19	9.60	10.12	21.30	41.02	58.98
	20—30	7.31	8.30	5.95	23.62	10.72	7.95	43.46	62.13	37.87
	40—50	5.37	8.22	10.05	23.76	7.63	9.18	41.16	57.97	42.03
	70—80	7.92	10.07	21.20	13.15	6.52	10.42	38.64	55.58	44.42
	110—120	19.64	4.80	13.69	14.62	8.89	11.96	46.14	66.99	33.01
Solod	0—5	5.10	20.24	8.70	33.57	9.86	11.65	15.98	37.49	62.51
	5—10	1.84	10.09	11.14	34.59	12.58	13.29	18.31	44.18	55.82
	20—30	2.81	13.07	10.90	25.54	7.84	11.58	31.07	50.49	49.51
	40—50	2.46	10.09	12.13	22.77	8.05	8.00	38.93	55.01	44.49
	70—80	2.86	8.85	7.48	23.97	7.56	9.85	42.29	59.70	40.30
	110—120	3.75	6.19	21.16	10.16	7.47	10.04	44.98	62.49	37.51
Gray solodized	2—5	3.93	7.48	12.66	36.64	12.93	14.12	16.12	43.22	56.78
	5—10	1.69	7.87	9.20	31.76	12.66	13.84	24.67	51.77	48.83
	20—30	2.41	13.28	20.24	18.79	6.43	10.82	30.44	47.69	52.31
	40—50	2.31	9.56	12.20	20.54	6.64	10.28	40.78	57.70	42.30
	70—80	2.07	7.69	10.34	24.74	6.57	8.99	41.67	57.23	42.77
Dark gray solodized	2—5	5.37	11.18	6.57	28.15	11.25	15.24	27.61	54.10	45.90
	5—10	3.57	8.22	8.61	27.09	10.40	15.70	29.98	56.08	43.92
	20—30	3.26	8.95	11.62	21.97	8.77	14.73	33.96	57.46	42.54
	40—50	2.58	9.19	9.74	21.69	10.46	11.03	37.89	59.38	40.62
	70—80	1.76	10.80	15.45	14.94	7.59	11.69	39.53	58.81	41.29
	110—120	2.58	10.01	8.54	20.08	9.66	18.47	41.24	61.37	38.63

Table 2

Composition of the water extract

Soil	Depth, cm	Solid Residue	Dried Residue	HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+ by difference	Total cations
		%		meq/100 g of absolutely dry soil						
Crusty solonetz	0—10	0.921	0.633	3.39	0.35	0.18	0.59	0.13	3.20	3.92
	20—30	2.072	1.482	11.24	0.41	0.44	1.23	0.25	10.61	12.09
	40—50	2.022	1.530	9.22	0.15	0.41	1.23	0.24	8.31	9.78
	70—80	0.536	0.302	8.13	0.15	0.13	0.49	0.24	7.67	8.42
	110—120	0.453	0.234	6.76	0.13	0.13	0.98	0.49	5.55	7.02
Solod	0—5	0.469	0.086	1.40	0.15	0.78	1.01	0.50	0.82	2.33
	5—10	0.156	0.041	0.52	0.08	0.18	0.24	0.12	0.42	0.78
	20—30	0.184	0.073	0.52	0.14	0.09	0.24	0.12	0.39	0.75
	40—50	0.110	0.026	0.73	0.05	0.13	0.49	—	0.42	0.91
	70—80	0.147	0.031	0.63	0.08	0.18	0.73	—	0.16	0.89
	110—120	0.185	0.042	0.95	0.04	0.14	0.74	—	0.39	1.13
Gray solodized	2—5	0.370	0.070	1.05	0.02	0.63	0.86	0.12	0.72	1.70
	5—10	0.226	0.093	0.41	0.06	0.27	0.49	0.25	—	1.70
	20—30	0.260	0.111	0.62	0.08	0.27	0.72	0.25	—	0.97
	40—50	0.201	0.057	0.73	0.04	0.13	0.49	0.36	0.06	0.91
	70—80	0.190	0.115	0.83	—	0.09	0.49	0.36	0.07	0.92
Dark gray solodized	2—5	0.304	0.111	1.17	0.01	0.46	1.25	—	0.39	1.62
	5—10	0.212	0.099	0.94	0.01	0.27	0.73	—	0.49	1.22
	20—30	0.206	0.106	0.84	0.01	0.23	0.49	0.36	0.22	1.07
	40—50	0.214	0.104	0.73	0.02	0.23	0.49	0.36	0.13	0.98
	70—80	0.255	0.059	0.62	0.03	0.09	0.63	0.12	—	0.74
	110—120	0.177	0.069	1.23	0.06	0.18	0.93	0.24	0.27	1.45

Table 3

Organic material content in the soils

Soil	Depth, cm	Total humus (Tyurin's method), %	Content of water soluble humus (Kubel'-Timon method), %	Water soluble humus as % of total humus	Total nitro content (Kjeldahl method), %	Hydrolyzed nitro. (Tyurin-Kononova method), %	Hydro. nitro. as % of total nitrogen
Crusty solonetz	0—10	2.79	0.114	4.85	0.168	0.007	4.34
	20—30	2.64	0.161	6.09	0.117	0.003	2.91
	40—50	1.93	0.117	6.06	0.072	0.002	2.36
	70—80	0.73	0.052	7.12	0.031	0.001	1.93
	110—120	0.68	0.055	8.08			
Solod	0—5	23.90	0.157	0.65	1.150	0.021	1.80
	5—10	2.42	0.051	2.10	0.129	0.010	8.14
	20—30	3.06	0.040	1.30	0.149	0.006	3.93
	40—50	1.27	0.040	3.15	0.058	0.005	8.96
	70—80	0.74	0.034	4.59	0.046	0.001	2.39
	110—120	0.63	0.034	5.39			
Gray solodized	2—5	15.33	0.128	0.83	0.731	0.011	1.56
	5—10	5.56	0.065	1.17	0.232	0.007	2.54
	20—30	3.03	0.046	1.51	0.145	0.005	3.31
	40—50	1.90	0.045	2.37	0.101	0.004	3.96
	70—80	0.87	0.041	4.71	0.059	0.003	5.25
Dark gray solodized	2—5	14.95	0.086	0.57	0.714	0.011	1.56
	5—10	9.46	0.071	0.75	0.499	0.009	1.81
	20—30	6.18	0.049	0.79	0.277	0.006	2.35
	40—50	3.87	0.048	1.24	0.171	0.004	2.51
	70—80	1.73	0.042	2.42	0.100	0.003	2.60
	110—120	0.73	0.037	5.07			

seen in Table 3, solonetzes and solods have only small quantities of humus.

The humus content in the illuvial horizon was increased somewhat by leaching from the upper layer in solodization.

The high humus content in the 0-5 cm layer f the solod is explained by the fact that this ayer is the sod as well as the lower portion of he forest-litter horizon. It is obvious that he litter of aspen scrub is an important source of humus in the soils. In the soils of aspen-elm scrub, sod-formation is well advanced and humus gradually accumulates, beginning in the A_1 horizon and later in the A_2 and B_1 horizons. The total humus content in dark gray, slightly solodized soils increased sharply over the entire profile down to the B_2 horizon.

The sodium in the adsorption complex has an important effect on the content of water-soluble humus. For this reason a high content f water-soluble humus is observed in a solonetz having a low total humus content. The content of water-soluble humus decreases sharply in solod and exchangeable sodium disappears almost completely, although the total humus content is approximately the same as in a solonetz. The quantity of water-soluble humus increases in solodized soils, not because of the increased availability of the humus, but because of the total accumulation of humus. The contents of water-soluble humus expressed as percents of total humus indicate that the availability of humus decreases faster as the process of solodization proceeds. Total nitrogen content behaves in a similar manner. The relative content of hydrolyzed nitrogen increases significantly in solod and decreases in solodized soils.

Thus, because of the development of the sod-forming process in soils under aspen-elm scrub, humus and nitrogen accumulate but become less available. This process begins at the top and gradually spreads downward, so that the solodized horizon takes on a gray, and later a dark gray coloring. The distribution of humus throughout the profile becomes more even as soil formation proceeds. If a particular increase in the humus content is observed in a solod at a depth of 20-30 cm as compared with the solodized horizon, then this disproportion in its distribution becomes even in the gray solodized soil by the accumulation of humus. A dark gray, slightly solodized soil resembles the dark gray forest soils of broadleaf forests in amount of humus and its distribution throughout the profile. But in contrast to the dark gray forest soils, the humus of soils of aspen-elm scrub is less saturated with calcium.

A physical-chemical analysis of our soils supports the conclusion of Gedroyts about the solodization of carbonate solonetzes and permits the variation in the amount and composition of the adsorbed cations to be detected during the solodization of solonetzes and the evolution of solods as they occur in the southern Oka-Don lowland. The adsorbed cations were determined after Gedroyts by displacing with 1 N ammonium acetate; the sum of Ca + Mg and Ca was titrated with trilon; Mg was determined by difference. The composition of the adsorbed cations in effervescent samples was determined by Shmuk's method. Water-soluble Ca and Mg also enter into the composition of the adsorbed calcium and magnesium. Exchangeable Na was determined in weighed samples washed from the water-soluble salts with 50% alcohol. The data obtained are shown in Table 4.

A crusty solonetz is characterized by a comparatively small adsorption capacity in the eluvial horizon. This capacity increases noticeably in the illuvial horizon. Na^+, which is at maximum concentration from 20-50 cm, is the predominant exchangeable cation.

The cation ratio throughout the profile of a solonetz is not the same; but in all genetic horizons, with the exception of the 0-10 cm layer, the relative sodium content is highest. A high content of exchangeable magnesium is also characteristic. The relative role of Ca^{++} begins to increase in the parent material as the content of adsorbed magnesium decreases.

Solodization completely removes exchangeable sodium from the adsorption complex of the A_1 and A_2 horizons, and the absolute amount of sodium in the rest of the profile decreases sharply. At the same time, Ca^{++}, which becomes noticeably more important throughout the entire profile, is introduced into the adsorption complex. The smallest adsorption capacity and minimum amount of exchangeable calcium are noted in the A_2 horizon. This agrees completely with the content of humus and clay particles here. Exchangeable calcium throughout the profile of a solod may be ascribed to mineralization of the forest litter and to the periodic rise of hard ground water into the soil profile. In addition to calcium, solodization also introduces into the adsorption complex exchangeable hydrogen, which decreases in concentration evenly with depth. The corresponding role of exchangeable hydrogen is especially noticeable in the solodized horizon.

As soil formation proceeds under aspen-elm scrub an increased accumulation of adsorbed calcium is especially marked in the upper portion of the soil profile. This is easily detected by comparing the results of physical-chemical analyses of solods and solodized soils for 5-10, 20-30, and 40-50 cm depths.

Exchangeable sodium disappears from the adsorption complex of solodized soils throughout almost the entire profile, while the content of exchangeable hydrogen decreases regularly. These changes are also observed in a ratio of hydrolytic acidity. Because of the accumulation of exchangeable calcium and magnesium and the decrease of hydrolytic acidity, a gradual increase in the base saturation of solodized soils is observed. Minimum saturation is noted in the A_2 horizon.

Conclusions

1. The solods formed from crusty carbonate solonetzes in the southern Oka-Don lowland develop according to the following scheme: solod—gray solodized soil—dark gray solodized soil. The evolution of the solods in this direction is closely connected with the invasion of broadleaf trees into the aspen scrub, their thinning, and the development of grass in the scrub. Increased local drainage and a lower water table play an important role in the evolution of the solods.

2. The evolution of solods under aspen-elm scrub is accompanied by the following:

a) an increase in the thickness of the humic-accumulative horizon and the gradual improvement of its structure;

b) a secondary accumulation of clay in the elluvial horizon because of the rapid recent development of sod;

c) an accumulation of humus and nitrogen but a decrease in their availability, initially in the upper layer of the soil and later in the remainder of the soil profile;

d) a saturation of the adsorption complex with exchangeable calcium, a decrease in

Table 4

Physical-chemical properties of the soils

Soil	Depth, cm	Ca^+	Mg^{++}	Na^+	H^+	$Ca^{++} + Mg^{++} + Na^+ + H^+$	Ca^+	Mg^{++}	Na^+	H^+	Hydrolytic acidity, meq/100g of soil	Degree of saturation, %	CO_2, %
		Meq/100 g of dry soil					% of total meq of exchangeable cations						
Crusty solonetz	0—10	7.83	4.70	7.19		19.72	39.71	23.83	36.46				
	20—30	1.60	6.41	20.60		28.61	5.59	22.40	72.01				0.71
	40—50	3.18	4.82	17.81		25.81	12.32	18.67	69.01				0.37
	70—80	3.18	9.53	11.67		24.38	13.04	39.09	47.87				1.31
	110—120	6.35	7.93	6.87		21.15	30.02	37.50	32.48				6.05
Solod	0—5	44.00	6.15	—	0.86	51.01	86.26	12.05	—	1.69	12.04	80.64	—
	5—10	9.62	2.24	—	0.64	12.50	76.96	17.92	—	5.12	6.19	66.78	—
	20—30	16.87	4.21	0.41	0.30	21.79	77.42	19.32	1.88	1.38	5.64	79.21	—
	40—50	15.33	5.41	1.26	0.35	22.00	69.68	24.59	5.73	1.60	3.67	85.50	—
	70—80	18.03	5.70	2.94	0.35	27.02	66.73	21.10	10.88	1.29	2.88	90.25	—
	110—120	21.51	5.43	2.53	0.13	29.60	72.67	18.34	8.55	0.44	1.47	95.24	—
Gray solodized	2—5	31.58	6.01	—	0.64	38.23	82.61	15.72	—	1.67	10.65	77.92	—
	5—10	13.27	5.16	—	0.30	18.73	70.85	27.55	—	1.60	7.66	70.64	—
	20—30	16.84	4.08	—	0.21	21.13	79.70	19.31	—	0.99	4.35	82.78	—
	40—50	18.93	5.41	0.11	0.34	24.79	76.36	21.82	0.44	1.38	3.77	86.55	—
	70—80	17.23	5.90	0.74	0.25	24.12	71.43	24.46	3.07	1.04	2.30	91.21	—
Dark gray solodized	2—5	46.20	7.29	—	0.45	53.94	85.65	13.52	—	0.83	5.67	90.41	—
	5—10	32.45	6.61	—	0.42	39.48	82.19	16.74	—	1.07	6.61	85.53	—
	20—30	27.46	5.77	—	0.27	33.50	81.97	17.22	—	0.81	5.50	85.80	—
	40—50	21.43	6.73	—	0.31	28.47	75.27	23.64	—	1.09	3.93	87.75	—
	70—80	16.58	5.38	0.32	0.25	22.53	73.59	23.88	1.42	1.11	1.93	92.03	—
	110—120	19.22	5.66	0.56	0.16	25.60	75.08	22.11	2.19	0.62	1.34	95.00	—

hydrolytic acidity, and an increase in the base saturation of the soils.

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DISCUSSION

OMMENTS ON THE ARTICLE BY YE. N. IVANOVA ND N.N. ROZOV, "STAGE AND DEVELOPMENT F THE CLASSIFICATION PROBLEM IN SOIL SCIENCE"[1]

S. SMETANIN

The authors of the article assert that "two proaches to the various problems of soil ience have been developed — the morphologil-physicochemical approach and the genetic proach." We assume that the genesis and assification of soils has always been based on study of the morphological, physical, chemil, and physicochemical properties of soils and their development in time and space. Therere, emphasizing the fact that "in solving the il classification problem the only correct proach for purposes of generalization is the netic approach," is superfluous from our point view. At the present stage of development of il science no one will deny the vast impornce attached to the morphological features of ils, and the need for a close study of all the operties of soil profiles for resolving probms in the genetic classification of soils.

Several problems in the soil classification of nskaya Oblast' are inaccurately set forth in e article. These were adopted by soil scients of the Oblast' Administration for Agriculre and given our personal attention.

In the classification by the soil scientists of nskaya Oblast' Agricultural Administration e peat-podzolic soils have been separated om the podzolic soils not as a special group, the authors of the article write, but as a soil bgroup of the podzolic group.

The carbonate chernozems in the systematics Omskaya Oblast' Agricultural Administration re never differentiated "as an independent il group" but were regarded only as one of e chernozem subgroups. Presently, relative introducing into the taxonomic subdivision stem the concept of soil genus, we must nsider the carbonate chernozems as a special nus in the subgroup of ordinary chernozems, veloped on tertiary carbonate clay.[2]

Regarding the assertion by the authors of the article that "solonetzic chernozems and solodized chernozems are under special solonetz and solodi soil groups," we must point out that in the Omsk systematics soils with a varying degree of solonetzization (one subgroup) and various solonetzes (another subgroup) belong to the category of the solonetzic-saliferous soil group but not, in our opinion, the solonetzic chernozems. Soils with a varying degree of solodization belong to the solodi group, including the solodi, but not the solodized chernozems which Omsk soil scientists do not find in the Oblast'. They even consider that the possibility of soil solodization must be ruled out under the physicogeographical conditions required for the formation of chernozems. On the other hand, we do note the sod processes or the "chernozemnification" of solodi and solodized soils; in this case the soils receive appropriate designations, for example, dark-gray slightly solodized, gray solodized or sod-covered solodi.

By incorporating into the chernozem group the solodized and solonetzic soils, many that are lower in fertility than several solonetzes, we form a group of chernozem soils so broad, indistinct and indefinite, that the group cannot be kept within the definition of "soil group" as given by the First Plenum of the Joint Committee on the Nomenclature, Systematics and Classfication of Soils, Academy of Sciences, USSR (Pochvovedeniye, 1957, No. 8). We know which soils are differentiated in the Oblasts adjoining the Omskaya Oblast', e.g., the Tyumenskaya and Kurganskaya Oblasts, designated as "solodized and solonetzic chernozems"; we know how removed these soils are from chernozems in their properties, fertility and agricultural use, and thus we are constantly on guard against committing the grave error of incorporating the solonetzic and solodized soils into the chernozem group. The Joint Committee should turn to this problem and arrive at a different decision.

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[1] Pochvovedeniye 1958, No. 10.

[2] According to data obtained from the authors of the article, Ye.N. Ivanova and N.N. Rozov, the classification and soil nomenclature scheme of the Omskaya Oblast' sent to them had not been adequately or carefully formally constructed; as a result the taxonomic coordinations had been violated. Editor.

The meadow-chernozems like the chernozem-meadow soils are in the Omskaya Oblast' systematics, a subgroup within the independent group of sod-meadow soils.

In overcoming the existing discrepancies in classification and nomenclature problems, at the present stage of development, it is most important to establish unity in views and concepts, first, among soil scientists of vast physico-geographical regions, such as the Western-Siberian lowland, the Urals, etc. Next, we should agree upon and coordinate the local classifications among adjoining regions and also continue those fruitful generalization activities in soil classification on an All-Union scale as listed in the article.

We assume that the time is ripe to summon conferences of soil scientists representing the separate regions, similar to earlier meetings in the Urals which were extremely useful at that time.

One great shortcoming is the absence not only of a single soil classification but also of a single representation of the structure of soil profiles and of the morphologic-physicochemical properties of even those soil subgroups and genera that are universally recognized. For example, some soil scientists refer to the very same soil as southern chernozem, while other soil scientists call it dark chestnut soil; the same soil profile is described by some soil scientists as sod-podzolic while others refer to it as gray (or light-gray) forest soil. Particularly great are the differences in the concept of subgroups and genera of soils that are transitional between groups.

The differences in the concept of the nature of soil subgroups and genera observed even among leading soil scientists, prevent evolving a single universally acknowledged soil classification. We consider as the most urgent and important task of the Joint Committee to devise a diagnostics of soils, a classification that will be universally recognized, and to publish this diagnostics for universal consideration as soon as possible, and approve it as a compulsory standard to be followed by all soil scientists.

In working out a soil diagnostics, we must employ the method of soil monoliths extensively. Members of the Joint Committee should select the soil profile in the field typical for one or another group, subgroup and genus, take the monoliths from such a jointly studied profile number, produce color photographs or sketches of the monoliths and send them to higher institutes of learning and scientific institutions. The soil horizon samples taken at the same time as the monoliths should be carefully analyzed in order that the characteristics of the physicochemical and agronomic properties of the standard monolith will be given together with a pictu of its morphological structure. By thus formulating standards and extensively propagating common obligatory diagnostics, we can quickly eliminate differences of opinion.

Another urgent and important task of the Joint Committee establishing intragroup subdivisions for each soil group is to establish the necessary subgroup genera, species and other classification divisions along with diagnostics of each of them. The urgency and importance of this work stems from the fact that only after an accurate uniform intragroup division can we approach a rational scientifically basic agricultural production classification of soils — a job most essential to production. The V. V. Dokuchayev Soil Institute, Academy of Sciences USSR should direct this work.

The need of establishing agricultural productivity regional classifications of soils comes from the fact that even the most perfect genetic classification cannot properly reflect the practicable and most expedient means of using and improving soils. For example, in the genetic soil classification, crust-like, shallow columnar, medium columnar and deeply columnar solonetzes fall into the solonetz group. From all of them it is evident that in fertility, methods of use and principal means for improvement the deeply columnar solonetzes resemble chernozems and can be united with them into one agricultural productivity group, whereas the crust-like and shallow columnar solonetzes, by necessity, fall into other agricultural productivity groups.

We shall allow ourselves to make several remarks concerning the soil systematics schemes published in the report by Ye. N. Ivanova and N. N. Rozov.

As to whether the principal general can be found within all the differentiated subgroups is not clear from Tables 1 and 2.

Despite the fact that most members of the Joint Committee decided to differentiate the podzolic-bog, sod-gley (taiga forest) gray fores gley, meadow-chernozem and meadow-chestnut soils as special independent soil groups, such a differentiation seems to us to have little basis. These are transitional soil groups; they should be regarded as subgroups just as the podzolic chernozems are considered as an intermediate (transitional) subgroup between chernozems and gray forest soils.

If we divide the bog soils into groups, we should distinguish among them not two, but at least three groups: 1. Upland bog soils; 2. Lowland bog soils of interfluves; and 3. Lowlan

d plain bog soils. The latter must be divided
a special group, because their genesis,
amics, properties, agricultural uses and
hods for improving them differ from the bog
s of the interfluves. When we differentiate
groups of bog soils we must indicate the
kness and character of the peat deposit;
erwise, there is no basis for dividing the
mentioned subgroups within the lowland bog
group.

Ve should exclude within the gray forest soil
up the genera of residual-podzolic and sec-
ary-podzolized soils. These add an indefi-
or undetermined character to this group
are responsible for the merging of gray
est soils with the sod-podzolic. There is
y little justification for dividing these soils.

Within the chernozem group, by preserving all the differentiated subgroups, we should exclude the genera: residual-podzolic, residual-solodi, residual-solonetzic and solonetzic. Then the chernozem group of soils will be specific.

If the meadow-chernozem soils are to be regarded some day as a special independent group or as a subgroup, in either case we should exclude from this group the genera: solodi, solonetzic and solonchak-like, as in the case of chernozems.

It is hoped that our remarks, based on many years' experience with large-scale mapping of soils, will become a subject of discussion and that they will bring forth comments, particularly from soil scientists and managers.

METHODS

MOLYBDENUM IN SOILS, COTTON PLANTS, IRRIGATION AND GROUND WATERS OF THE GOLODNAYA STEPPE

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In connection with the resolution by the Party and the Government "on irrigation and cultivation of virgin-lands of the Golodnaya steppe, Uzbek SSR, for increasing cotton production" there arises a problem regarding the chemical study of soils designated for cultivation. To expose fully the potential soil fertility contents of Golodnaya steppe, we must study the total content and forms of the micro-elements in these soils.

This report discusses the results of studying molybdenum distribution in soils of Golodnaya steppe, cultivated to varying degrees, in cotton plants grown on them, and in irrigation and ground waters.

An important physiological and biochemical role of molybdenum has been established from investigations of Bobko (1), Vinogradova (3), and Drobkov (7). It has been noted that molybdenum is of particular importance for legumes. The great importance of molybdenum for the synthesis of albuminous substances in plants, particularly for the process of reducing nitrate nitrogen has been demonstrated; the positive effect of molybdenum on the activity of Azotobacter and on the yield of a number of crops (12, 13, 19, etc.), has been established.

The first information on molybdenum in soils was fragmentary and made it impossible to reveal the distribution patterns, molybdenum accumulation and migration in soils.

The first systematic studies of molybdenum in soils were made by Vinogradov and Vinogradova (5), who studied the profiles of all zonal soils of the Russian plain. From their data the molybdenum content in the soils varies between 1.5×10^{-4}% and 1.2×10^{-3}% and is, on an average, equal to 2.6×10^{-4}%. It was noted that the upper humus horizon was enriched by molybdenum.

Robinson and Alexander (26) report that the average molybdenum content in soils, computed by them as based on 237 soil analyses of Argentina, 53 soil analyses of the Russian plains, and on 500 soil analyses of U. S. A., North Africa, Alaska, and Australia was equal to 2.5×10^{-4}%.

P. V. Madanov and Ivanova (11) determined the total molybdenum content in the profiles of soils typical of the Volzhsko-Kamskaya Steppe. It varies between 2×10^{-4}% and 6×10^{-4}%, where the maximum molybdenum content occurs on the A Horizon, while the minimum molybdenum content occurs in the parent material. Rudin and Shcherbakova (16) found that there is, on an average, 2.46×10^{-4}% molybdenum in the dark-chestnut soils of the Stavropol'skiy Kray and 1.7×10^{-3}% molybdenum in the solonetzic soils.

From Ya. V. Peyve's (13) data, total molybdenum content in the soils of Latvia varies between 2×10^{-5}% and 1.4×10^{-4}%. It was established that on many acidic sod-podzolic soils molybdenum micro-nutrient fertilizers were highly effective.

Molybdenum deficiency or excess in soils has an effect on plants, animals and humans. In regions where molybdenum content in soils is less than 1×10^{-4}%, we observe a plant sickness called "Whiptail" (22, 21, etc). In localities where molybdenum content in soils is above 2×10^{-3}%, this element appears in large amounts in a number of plants; animals are stricken with "Molybdenosis" (heart disease) (6), and human beings are afflicted with gout (2). Evans, Purvis and Bear (24), and others established that molybdenum compounds are easily available in soils having a pH above 7 and less available and little accessible to plants in acid soils. Kedrov-Zikhman (9) found that liming acid soils aids in mobilizin soil molybdenum and does away with the plant sickness "Whiptail."

We can distinguish the following forms of molybdenum in soils:

1) Unavailable molybdenum being retained

n a crystalline lattice of primary and secondary inerals; 2) Exchangeable molybdenum, adorbed as $MoO_4^=$, the availability of which deends upon the pH of the soil solution; 3) Molybenum associated with the organic matter of oils; 4) Water-soluble molybdenum, in the orm of molybdates of alkali metals and amonium (molybdates of other metals, as a rule, re insoluble in water).

General Characteristics of Soils Under Study

The Golodnaya steppe is characterized by a at relief and homogeneous soils, mostly light ierozems, developed in loess-like clay loam nd differing in the degree of salinization and ultivation.

The following features are peculiar to the esert zone where these soils have been deeloped: a general lack of moisture and the ossibility of cultivation only by irrigation; a igh and long insolation; upward flows of soil nd subsoil solutions; an alkaline character of e soil solution; a high oxygen potential, conucive to high degrees of oxidation; strongly arbonate soils; a comparatively small organic ontent in the soils; a high microbiological ctivity under moisture conditions (14, 15, 17, tc.).

The sampling site is shown on the attached chematic map (Fig. 1) of the Golodnaya Steppe. description of soil Profile Nos. 1, 2, 3, 5, 6, nd 18 is given in Table 1. All determinations f molybdenum in soils, plants and waters were ade after appropriately preparing the molybenum thiocyanogen complex by photocolorietric analysis following Dobritskaya's method). Photocolorimeter FK-53 was used in the ork.

Total Molybdenum Content in Soils Under Study

The results in Table 1 show the following:

In light nonsalinized sierozems, with deep round waters, the total amount of molybdenum y profile varies between $2.0 \times 10^{-4}\%$ and $5.2 \times$ $0^{-4}\%$. On virgin soil we note an increase (as ompared with the same soils of ancient irrigaon) content of total molybdenum, especially the deep horizons.

The light sierozems, salinized with ground aters at a depth of 3-4m, have an increased mount of total molybdenum (Profile No. 2) on e virgin soil along the entire profile up to 1m. hen similar soils are cultivated over 4-5 years oil salinization decreases as a result of a numer of agricultural practices (leaching, etc.), d the total molybdenum content drops somehat, especially in the A Horizon. Fifty years of cultivation has lowered the molybdenum content in the entire soil profile considerably.

"Available" Molybdenum: Most important for agronomic purposes is the determination of the forms of soil molybdenum assimilated by plants: the water-soluble and the exchangeable extracted with salt solutions.

To determine "available" molybdenum in the soils under study we have employed the method of Grigg (25) who proposed extracting "available" (water-soluble plus exchangeable) $MoO_4^=$ by a buffer mixture of oxalic acid and ammonium oxalate. This method is as follows: to 25g of air-dried soil in a 500ml Erlenmeyer flask we add 250ml of a buffer mixture (24.9g of ammonium oxalate and 12.605g of oxalic acid are dissolved in one liter of twice distilled water and the pH of the solution is brought to 3.3); the content of the flask is agitated by a rotator for 24 hours, and then filtered. Two-hundred ml of a clear filtrate is evaporated in a porcelain dish and the residue of the organic compounds is in a muffle at a temperature up to 450°C. The ignited residue is dissolved in 10ml of twice distilled water and 10ml of 22% HCl during preheating and filtered into a 50ml volumetric flask through a dense filter, which is rinsed with hot twice distilled water, acidified with HCl. Then molybdenum is determined according to Dobritskaya's method (8).

Grigg considers this method convenient for revealing the areas of "available" molybdenum content in soils that are deficient or excessive for plants.

By using Grigg's method with New Zealand soils having insufficient amounts of "available" molybdenum for grass Walsh, Neenan and O'Moore (27) obtained figures ranging from $4 \times 10^{-6}\%$ to $1.2 \times 10^{-5}\%$; with a normal and excess content of "available" molybdenum in the soils the quantities of molybdenum vary between $2 \times 10^{-5}\%$ and $7 \times 10^{-5}\%$.

When applied to carbonate soils Grigg's method has several shortcomings (an interaction of a buffer mixture of oxalic acid and ammonium oxalate with Ca^{++} precipitates CaC_2O_4; different amounts of calcium in the soils affect the concentration of $C_2O_4^=$ in the solution, etc.). But considering the small magnitude of the solubility product of CaC_2O_4 (2.57×10^{-9}), by adding a large excess of a buffer oxalic acid mixture, we get an extract of $MoO_4^=$ in the solution, in addition to complete precipitation of the calcium ion. Repeated extractions of an oxalic acid mixture on the same soil showed that all the "available" molybdenum is in the first extract.

The results of determining "available" molybdenum (Table 1) show that the pH in the extracts of an oxalic acid mixture from the soils studied varies between 3.8 and 5, i.e., corre-

Table 1

Molybdenum content and its forms in light sierozems of Golodnaya Steppe, in %, on an air-dried weighed soil

Profile No.	Sampling site	Soil	State of soil cultivation	Horizon	Depth, cm	Solid residue, %	Total amount of molybdenum	Oxalic acid extract		% of "avail." Mo to total Mo	Water extract		% of water-soluble molybdenum	
								pH	"Available" molybdenum		pH	Water-soluble molybdenum	to total molybdenum	to "avail." molyb.
1	Central loess area	Light sierozem, nonsalinized, medium clay loam, on loess-like clay loam. Ground water at depth of 17 m	Virgin soil	A	0—18	0.26	2.4×10^{-4}	4.0	2.0×10^{-5}	8.3	7.3	3.5×10^{-5}	1.4	17.5
				B	18—28	0.28	3.8×10^{-4}	4.5	2.8×10^{-5}	7.3	7.3	6.5×10^{-6}	1.7	23.2
				B	28—40	0.130	4.0×10^{-4}	4.5	3.4×10^{-5}	8.5	7.3	6.5×10^{-6}	1.6	19.1
				B	40—50	0.160	4.9×10^{-4}	4.0	3.1×10^{-5}	6.3	7.4	1.0×10^{-5}	2.0	32.1
				C	90—100	0.180	5.2×10^{-4}	4.0	4.0×10^{-5}	7.6	7.4	1.3×10^{-5}	2.3	32.5
6	Northern course of Kirov Canal. Kolkhoz imeni. Il'icha	Light sierozem, nonsalinized, medium clay loam, on loess-like clay loam; ground water deep	Irrigated over 50 years	A	0—28	0.287	2.8×10^{-4}	4.5	2.0×10^{-5}	7.1	7.4	Traces		
				B	28—42	0.170	2.4×10^{-4}	4.5	1.9×10^{-5}	7.9	7.4	"		
				C	90—100	0.120	2.0×10^{-4}	5.0	2.2×10^{-5}	8.5	7.4	"		
2	Southern area. Western part of course of Yuzhnyy Golodnostepskiy Canal	Light sierozem, salinized silty clay loam on stratified deluvium and proluvium; ground water at depth of 4 m	Virgin soil	A	0—16	2.180	5.0×10^{-4}	3.8	2.6×10^{-5}	5.2	7.1	1.0×10^{-5}	2.0	38.5
				B	16—30	2.125	4.2×10^{-4}	3.8	2.6×10^{-5}	4.7	7.1	1.0×10^{-5}	2.3	38.5
				B	30—40	2.100	5.4×10^{-4}	4.0	4.1×10^{-5}	7.6	7.1	1.6×10^{-5}	2.9	41.3
				B	40—50	3.080	4.9×10^{-4}	4.0	4.6×10^{-5}	9.3	7.1	1.9×10^{-5}	3.9	41.3
				C	90—100	2.730	5.3×10^{-4}	4.0	4.0×10^{-5}	7.5	7.1	2.1×10^{-5}	3.9	52.2
3	Southern area, eastern part. Sovkhoz Bayaut No. 4	Light sierozem, salinized, upper horizons irrigated. Medium clay loam on loess-like clay loam; ground water at depth of 4 m	Irrigated 5 years	A	0—28	0.182	3.6×10^{-4}	4.0	3.4×10^{-5}	9.4	7.4	1.1×10^{-5}	3.0	30.6
				B	28—45	0.236	3.8×10^{-4}	4.0	3.4×10^{-5}	8.9	7.4	6.6×10^{-6}	1.7	19.1
				C	95—100	2.100	4.1×10^{-4}	4.0	4.4×10^{-5}	10.6	7.4	6.5×10^{-6}	1.5	14.7
5	Mirzachul'skiy rayon. Kolkhoz imeni. Oktyabrya	Light sierozem, earlier salinized, upper horizons irrigated, medium clay loam on loess-like clay loam; ground water at depth of 4 m	Irrigated over 50 years	A	0—30	0.200	2.4×10^{-4}	3.8	1.5×10^{-5}	6.7	7.1	Traces		
				B	30—50	0.340	1.8×10^{-4}	3.8	1.0×10^{-5}	5.9	7.1	"		
				C	95—100	0.760	1.7×10^{-4}	4.0	1.2×10^{-5}	7.0	7.1	"		
18	Pakhta-Aral. Experimental station. Soyuz (NIKHI)	Light sierozem, salinized, fine clay loam on loess-like clay loam; ground water at depth of 210 cm	Young fruit garden, alfalfa between the trees	A	0—19	1.100	5.0×10^{-4}	4.5	2.0×10^{-5}	4.0	7.4	6.6×10^{-6}	1.3	32.5
				B	20—30	1.120	4.0×10^{-4}	4.5	1.9×10^{-5}	4.7	7.4	Traces		
				C	100—110	1.230	4.0×10^{-4}	4.5	1.5×10^{-5}	3.7	7.4	"		

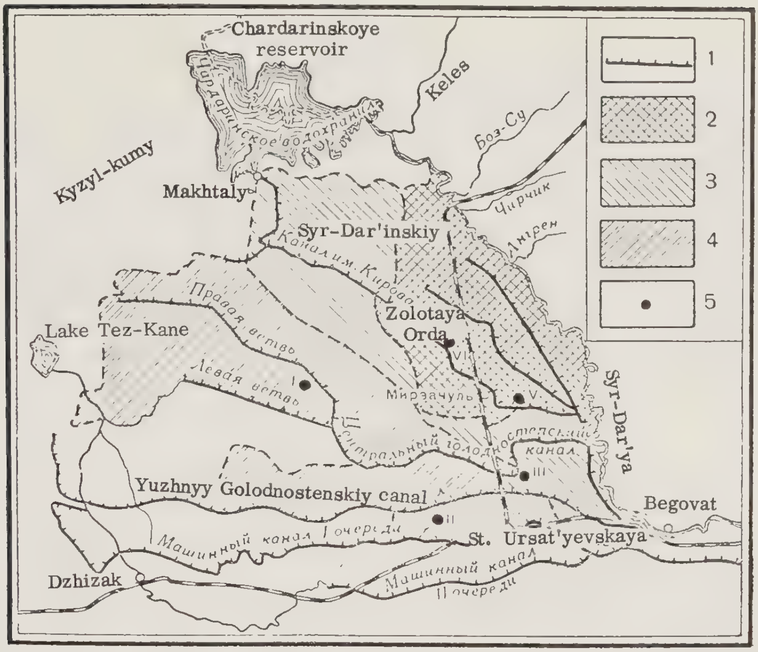

Fig. 1. - Schematic map of the Golodnaya Steppe

Symbols

1 - Irrigation canals; 2 - lands reclaimed before 1917; 3 - lands reclaimed after 1917; 4 - reclaimable lands; 5 - soil profile numbers

onds approximately to the pH of the root se-
etions of the cotton plant.

The "available" molybdenum content varies
tween 1 x 10^{-5}% and 4 x 10^{-5}%. We find no
rect relationship between "available" molyb-
num and the total molybdenum content in
ils. We do not find any particular differences
the content of "available" molybdenum in light
rozems, salinized and nonsalinized. In com-
rison with virgin soils, continuously irrigated
ht sierozems have reduced amounts of "avail-
le" molybdenum. The percentage of "avail-
le" molybdenum to total molybdenum varies
tween 3.7% and 10.6% and is equal, on an
erage, to about 7%. By profile the percentage
"available" molybdenum to total molybdenum
ries differently.

Water-Soluble Molybdenum: The soils under
dy have an alkaline pH of soil solution and
ortion of the molybdenum is found in these
ls in a water-soluble form, i. e. in the form
molybdates of alkali metals and ammonium.

To determine water-soluble molybdenum the
lowing method was used. Weighed portions
25g of air-dried soil were treated with 250ml
twice distilled water and shaken by rotator
30 minutes, then left standing for 23 hours
again agitated for 30 minutes. The solution
s filtered through a dense filter and 200ml of clear filtrate was evaporated in porcelain dishes. The organic matter of the extracts was ignited in a muffle at a temperature up to 450°C. The ignited residue was dissolved in 10ml of twice distilled water, 10ml of 22% HCl and after heating was filtered into 50ml volumetric flasks. Then the molybdenum was determined as described by Dobritskaya (8).

The data in Table 1 show that the pH of water extract from the soils under study varies between 7.1 and 7.4. The water-soluble molybdenum content varies within the limits of 1 x 10^{-6}% and 1 x 10^{-5}%, amounting to 1%-4% of the total amount of molybdenum. On old irrigated light sierozems the water-soluble molybdenum content was less as compared with virgin soil. Exchangeable molybdenum prevails over water-soluble molybdenum.

Molybdenum in Cotton Plants: Studies have revealed that plants play a role as accumulators of molybdenum (2).

The cotton plant samples studied were taken from the fields where the profile numbers of the previously described soils had been laid out.

The figures in Table 2 show that a cotton plant accumulates most molybdenum in the leaves, followed by seeds, bolls and stems. The amount of molybdenum in the fiber is less

Table 2

Molybdenum in cotton plants, in %

Profile No.	Soil	Leaves	Stems	Bolls	Seeds	Fiber
3	New irrigated (4 years)	5.6×10^{-4}	1.3×10^{-4}	1.5×10^{-4}	1.7×10^{-4}	Traces
5	Old irrigated (over 50 years)	2.0×10^{-4}	8.0×10^{-5}	1.1×10^{-4}	1.6×10^{-4}	"
6	Same	2.3×10^{-4}	6.6×10^{-5}	1.2×10^{-4}	1.6×10^{-4}	"

Table 3

Molybdenum removed by cotton plant crop

Profile No.	Soil	Yield of raw cotton cntr/ha	Molybdenum removed, g/ha				
			Leaves	Stems	Bolls	Seeds	Total
3	New irrigation	26.0	7.94	1.35	1.56	2.89	13.71
5	Old irrigation	36.0	3.44	1.15	1.58	3.77	9.94
6	Same	33.0	3.63	0.87	1.58	3.44	9.52

than 1×10^{-6}%.

We see a direct correlation between the molybdenum content, especially in the cotton plant leaves, and the "available" molybdenum content in soils. The greatest amount of molybdenum has been found in the leaves of a cotton plant grown on soil (Profile No. 3) with the greatest amount of "available" molybdenum.

Table 3 (10) shows estimate of molybdenum loss from soils and cotton crop.

Molybdenum in Irrigation and Ground Waters: One of the sources of molybdenum intake into the soils being studied is irrigation waters. With irrigation waters molybdenum can migrate both in the ionic form and as suspended residue-clay.

The determinations of molybdenum in filtered irrigation canal water showed that molybdenum quantities are expressed by figures of an order of 1×10^{-6} g/l (Table 4). The filtered ground waters are strongly mineralized and the molybdenum content in them is higher than in the irrigation waters (Figures of an order of 1×10^{-5} g/l).

These data show that the possibility of increasing molybdenum content in soils with capillary rise of these ground waters near the soil surface cannot be ruled out.

Conclusions

1. The average total content of molybdenum in virgin, salinized light sierozems of the Gol naya Steppe is higher than that in soils indicat by A. P. Vinogradov, and is equal to 4.5×10^{-4} According to A. P. Vinogradov the average content of molybdenum in light sierozems, non-salinized, and irrigated for more than 50 year approaches the average amount of molybdenum and is equal to 2.6×10^{-4}%.

2. On virgin soil we do not observe any mol bdenum accumulation in the upper horizon. On when these soils have been cultivated over 50 years is a very small increase seen in the mol bdenum content in the upper horizon.

3. We observe a correlation between the m bdenum content in the cotton plant (especially the leaves) and "available" molybdenum in soi determined by the Grigg method. We found no direct relationship in the soils between the tot amount of molybdenum and the amount of moly bdenum available to plants.

4. The content of "available" amolybdenum in the soils under study varies between 1 x 10 and 4×10^{-6}%; the percentage of "available" molybdenum to the total amount of Mo is, on an average, 7%. Exchangeable molybdenum prevails over water-soluble molybdenum.

5. The amount of water-soluble molybdenu

Table 4

Molybdenum content in irrigation and ground waters, g/l

Profile No.	Sampling site	Water and depth	Solid residue, %	Molybdenum
6	Kolkhoz im. Il'icha	Irrigation canal	0.96	7.0×10^{-6}
5	Kolkhoz im. Oktyabrya	Irrigation canal	0.40	8.0×10^{-6}
1	Virgin soil	Gr. water 17.7 *м*	23.86	1.4×10^{-5}
3	Kolkhoz im. Oktyabrya	Gr. water 180 *см*	16.30	1.0×10^{-5}
6	Kolkhoz im. Il'icha	Gr. water 210 "	5.40	1.2×10^{-5}
5	Sovkhoz Bayaut No. 4	Gr. water 210 "	60.41	6.0×10^{-6}
8	Same	Gr. water 4 *м*	113.5	1.0×10^{-5}

ne light sierozems studied is of the order of 10^{-6}% and lower; therefore, an analytical ermination of water-soluble molybdenum is cult.

. Cotton plant leaves accumulate 36%-55%, ds 17%-29%, bolls 15%-22% and stems 11%- of the total amount of molybdenum in plants. noval of Molybdenum by cotton in the cases lied ranges from 9.5 to 13.7 g/ha. More- r, we must consider that cotton plant leaves, n they fall, remain on the ground and the ybdenum contained in the leaves return into soil.

. The amounts of molybdenum in irrigation igation canal) waters filtered from clay, es about 1 x 10^{-6} g/l. The ground waters ne Golodnaya Steppe are more frequently ngly mineralized and more enriched with ybdenum than the irrigation waters. The ybdenum content in the ground waters is ne order of 1 x 10^{-5} g/l. With the ground ers near the surface, secondary saliniza- of soils may take place, including their chment with molybdenum.

'he studies made enable us to conclude that on light, nonsalinized sierozems, irrigated a long time with ground waters near the ace is it possible to apply molybdenum ro-nutrients effectively.

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EVERAL PROBLEMS
N THE STUDY OF THE FERTILITY OF FOREST SOILS

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The problems involving the fertility of forest ils have thus far been studied little. In a sys- natic sense there is a perfectly natural con- ction with a field that is very related but con- lerably older and richer in experience — mely, agrochemistry. At the same time an proach to the study of the fertility of forest ils, particularly under natural forests, should flect the unique character of the subjects der study and their basic difference from ltivated agricultural soils. Forest vegetation s been described as plants of many years' nding, very different in biological properties om agricultural crops. These plants have a ferent overall life span and chemical compo- ion of organic matter, as well as a different igth of vegetation period. They have a differ- t structure, thickness, and penetration depth root system, annual return into the soil of ad organic matter (with coniferous needles, ives, and other residue) together with nutrient ments contained in the organic matter, and mation of a unique, genetic horizon of forest ils — the forest floor litter. All this deter- nes the different relationships and interaction ween forest vegetation and soils.

On areas used for agricultural crops, the l is comparatively alike and level because of stematic scientific agricultural measures.

In soils under natural forests, essentially gin lands, as a rule we see an extreme spa- l heterogeneity in the distribution of different ments. This is explained by the growth ocess of forest soils and of the forest growing them. When individual trees die during wind- ls, the upper part of the soil layer repeatedly nges under the influence of the activity of est animals and insects. Trunks or frag- nts of dead trees are scattered about and compose; in their place fairly deep holes are med; in other places animal burrows or ant mounds. Simultaneously, the soil surface levelled off and smoothed down. The earlier med uneven surfaces are filled with fallen ves, coniferous needles, dead branches and er residue. These phenomena take place continuously from the moment the forest exists on any given territory. Under a relatively smooth surface, the soil's history in a layer of forest soil is reflected both in terms of the general course and direction of the soil-forming process and as separate phenomena that have previously taken place on specific tracts. Therefore, it is natural that distribution of the individual components composing the forest soil (organic matter, mineral substratum, etc.) will not be even or uniform.

The specific characteristics of the formation of forest soil profiles and their spatial heterogeneity compel us to use extreme care in approaching the selection of sites for soil profiles for morphological description purposes and for taking samples for laboratory analysis and also in approaching a method for periodically taking samples in order to study the dynamics of the soil processes. Inadequate attention to these basic aspects in conducting any kind of studies often lowers the value of the work. Thus, in several works published by Tyulin and his co-workers (6, 7, 8) based on studies conducted at the Tellermanovskoye Experimental Forest of the Forestry Institute, Academy of Sciences, USSR (Voronezhskaya Oblast'), we see a marked seasonal content of the total nitrogen and phosphorus in the dark-gray forest soils of 25-year old oak forests. In the upper A_1[1] humus horizon (depth 3-13 cm) it was found that in May, N = 0.58% and P_2O_5 = 0.229%; in July, N = 0.37% and P_2O_5 = 0.091%; in September the original percentage was restored: N = 0.55% and P_2O_5 = 0.228%.

The greatest difference by periods, expressed for N of 0.21% and for P_2O_5 of 0.138% converted to 1 hectare, was 2,100 and 1,380 kg respectively. With such a loss of nitrogen and phosphorus and its total compensation towards the end of the vegetation period, the question naturally arises as to the causes of this loss and the sources for its replenishment in such a short period of time. Attributing the loss to the consumption of nutrients by forest vegetation, A. F. Tyulin supposed that the return into the soil of the nutrients was provided for by annual litter, root formations and dead roots.

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[1] We note that in a 20-30 cm layer, according to Tyulin's data, a similar dynamics of N and P_2O_5 was observed; consequently, a redistribution of these elements in the soil layer could not result in significant amounts.

The quantitative indicators for nitrogen and phosphorus being returned into the soil with the litter are easily determined and fairly accurate. In oak forests which are almost similar in age and soil conditions to those where Tyulin worked, about 50 kg N and 5 kg P_2O_5/1 ha (3) are returned annually with litter. The root formations, annually dying roots and the root tips have not as yet been subjected quantitatively. However, there is no reason to assume that these sources may completely provide for the restoration of the original contents of nitrogen and phosphorus in the soil, in amounts equal to the detected loss. The entire root mass in a 25-year-old oak contains only 225 kg N and 53 kg P_2O_5/1 ha, and the entire mass of organic matter in this wood (above-ground and below-ground) stores up or accumulates 425 kg N and 86 kg P_2O_5 (3) at this age, i.e., many times less than the previously-determined differences in the content of these substances in the soil during separate periods.

Thus, we cannot assume that variations in the total content of nitrogen and phosphorus for a vegetation period, in the dark-gray soils of a 25-year old oak stand, might attain values ranging from 1,300-2,000 kg/1 ha. There is no consumer for such a loss, just as there is no source for its replenishment.

Obviously, the reason for such marked variations in the total content of nutrients lies in the great diversity of distribution of the individual nutrients in the forest soils, especially in their upper horizons. This diversity excludes the possibility of studying any nutrient in the dynamics by analyzing single soil samples or a composite of several samples that have been taken from a limited area and which often give readings differing sharply from the actual mean values. In our opinion, this is also confirmed by data from Tyulin's work, already mentioned (8). Tyulin considered living roots as the principal cause for the loss of nutrients in the soil, and conducted observations on the dynamics of carbon and nitrogen contents in soil deprived of roots. Preparing soil for this experiment consisted of removing the litter and extracting all visible roots by hand. Next the soil was placed into a plot that has been spaded 15 cm; the sides of the plot were isolated with boards or slabs to prevent possible penetration by roots from without. Practically speaking, the seasonal variations of nitrogen in this experiment were absent. In his results Tyulin confirmed his conclusion on the role of living roots in the absorption of enormous amounts of nutrients from the soil. However, the results of this experiment may be considered from other viewpoints.

The actual preparation of the soil for experimentation and the careful sifting of soil in extracting roots made the soil homogeneous and free of a diversified distribution of the differen nutrients, (a diversity peculiar to forest soil), in their natural occurrence. Naturally, the successive analyses of soil samples taken during various periods did not reveal marked variations in the content of total nitrogen, while the actual experiment once again showed how important proper soil sampling is in studies of this kind.

Our observations of the dynamics of total content and available forms of nitrogen and phosphorus, conducted in 1953 at the same Tellermanovskoye forests on dark-gray forest soils with oaks of various age under conditions similar to those under which Tyulin made investigations, do not confirm his conclusions (Table 1).

Soil samples to be analyzed were prepared by mixing 20 samples taken by a borer from individual spots situated equally apart on the experimental plot.

The total nitrogen content in the soils of the different experimental plots was similar. The upper 10 cm layer of soil on experimental plot No. 1, under a 200-year old forest stand is characterized by a somewhat increased quantit of nitrogen. The maximum difference in nitrogen is 0.17%, with an average content of nitrogen for this layer equal to 0.70%. The percentage of nitrogen in the litter is approximately 3 times more than in the upper layer of the humus horizon. The quantity of nitrogen gradually decreases with depth.

A nitrogen loss (0.3% for all plots) was noticeable in the forest litter during the vegetative period, particularly from July through September.

From May to the end of June the nitrogen content in a 3-13 cm soil layer remained unchanged on Experimental Plots No. 10 and 11, while on Nos. 8 and 1 the nitrogen content increased somewhat (by 0.05%-0.10%). At the end of September a nitrogen loss was observed on Plots No. 10 and 11 a small loss (0.03%-0.04%), and on Plots No. 8 and 1 a more appreciable loss (0.12%-0.15%). At depths of 13-23 and 23-33 cm a nitrogen loss was noted as we moved from spring toward fall, a loss which quantitatively amounted to 0.11% for the entire period. The content of hydrolyzed nitrogen in the A Horizon is small — 7-15 mg N/100 ha of soil. In the litter it is considerably more, up to 80 mg. We did not observe any dependence

Table 1

Content of nitrogen and phosphorus in the humus horizon of dark-gray soils and its change during a vegetative period (1953)

Experimental Plot No. and age of forest stand	Depth, cm	Total N, %			Hydrolyzed N, Mg/100 ha			Total P_2O_5, %			Available P_2O_5, Mg/100 ha (after Truog)		
		May 9	June 30	Sept. 25	May 9	June 30	Sept. 25	May 9	June 30	Sept. 25	May 9	June 30	Sept. 25
10. 25 years	0—3	2.05	1.85	1.83	53	76	65	Not determined			95	82	92
	3—13	0.62	0.63	0.60	14	15	14	0.27	0.27	0.24	55	41	57
	13—23	0.40	0.37	0.34	12	13	13	0.20	0.22	0.23	54	44	45
	23—33	0.33	0.22	0.22	11	12	0,8	0.21	0.18	0.18	45	31	51
11. 43 years	0—3	1.88	1.85	1.55	69	72	83	Not determined			122	85	86
	3—13	0.62	0.63	0.59	13	15	11	"	"	"	46	36	37
	13—23	0.35	0.37	0.34	14	12	8	"	"	"	50	31	40
	23—33	0.28	0.24	0.20	8	11	7	"	"	"	32	30	33
8. 56 yrs.	0—3	1.89	1.89	1.59	56	65	76	"	"	"	126	79	86
	3—13	0.62	0.72	0.57	15	15	19	"	"	"	46	31	39
	13—23	0.40	0.35	0.30	11	9	16	"	"	"	30	29	37
	23—33	0.32	0.22	0.21	9	8	16	"	"	"	32	27	34
1. 220 yrs.	0—3	1.89	1.82	1.54	42	82	77	"	"	"	93	73	94
	3—13	0.75	0.80	0.68	14	15	14	"	"	"	37	26	35
	13—23	0.39	0.44	0.41	11	13	11	"	"	"	32	15	21
	23—33	0.28	0.27	0.22	9	9	11	"	"	"	35	22	27

the content of this form of nitrogen upon the e of the forest stands on the experimental ts or upon regular changes with season, cept an increased concentration during sumr months in the forest litters.

The available phosphoric acid shows in its tribution a definite relationship to the age of forest stands; the amount of P_2O_5 at all the mined A Horizons decreases as the forest e increases. This relationship can be seen all periods.

There are 2-3 times more phosphates in the ers than in the mineral horizons of the soil. do not see any relationship of the age of es to the litters. At all depths in the A Horia loss of available P_2O_5 towards the end of e and a restoration of the original amounts ards the end of September were noted; the d on Experimental Plot No. 1, where a total npensation of the summer loss had not been orded, was an exception. The magnitude of loss and of the subsequent restoration of the ount of available phosphoric acid was 410 1 ha for the upper 30 cm layer of soil on perimental Plot No. 10. We should attribute rge part of these changes to a temporary tion of P_2O_5 in the more stable compounds. e total amount of P_2O_5 actually remains unnged at all periods.

In order to eliminate the effect of spatial erogeneity in the distribution of the individual nponents in forest soils, Abramova (1) and later Zonn and Aleshina (2) used the following method. In studying the dynamics of the chemical and physicochemical properties they marked off an experimental section into 5 tracts; each was divided into 10 plots. Soil samples to be studied at each period were taken from each plot and mixed by tracts. Five samples were obtained per horizon; each sample represented the average of ten individual samples. All the average samples were subjected to analysis separately. One might suppose that this method would provide reliable analytical data. Yet, we failed in fully realizing this. In Abramova's work in Table 22, we find data on the change in the content of total humus. From these data, where each value has been derived from analyzing a sample prepared from 10 samples taken separately, the result was that the differences in the humus content, from the spatial heterogeneity in its distribution, were considerably greater than the change of humus content in time. This very fact of the variability of humus content during a vegetative period, which Kravkov and Remezov (5) had pointed out earlier, has been proven in Abramova's work. A similar trend in the changes of humus content on the separate tracts bears this out.

However, a quantitative expression of this variability in humus content as a result of spatial heterogeneity is not reliable. This applied as well to the work of Zonn and Aleshina (2). They showed that the difference in humus content in the A_1 horizon of dark-gray oak forest soils is 3.80% over a period of 2 autumn months. The existence of data on the thickness of the separate horizons and of the bulk density of these soils, as well as values for annual litter, makes it possible to come up with an approximate estimate. As a result the difference in the humus content in the upper 40 cm layer of these soils for a period of two months will be expressed as 6.1 kg per m^2, while the return of dead organic matter along with litter for the same section will be 0.35 kg.

The mass of living roots having a diameter less than 2 mm amounts to 3.6 kg per m^2 (3) in a forest stand similar in composition, age and forest conditions to those studied by Zonn and Aleshina. Dead roots were not considered but there were fewer of them than living roots. The work of Orlov (4) with spruce stands on leached chernozems of the forested steppe gives some idea of the quantity of dead roots. About 6 metric tons/1 ha of dead roots, i.e., 0.6 kg per m^2 were found in a 2 m layer of soil on a 50-year old spruce plantation. Thus, the possible sources for supplementing the quantity of humus are only a small part of the loss, as indicated by the work of Zonn and Aleshina (2).

We might offer the following recommendation for sampling. The average samples should be prepared by mixing the separate samples (for each horizon, for each period). The number of mixed samples can be determined based on the foregoing study of the spatial heterogeneity effect on the soil; only after we have statistically computed the results of such a preliminary work can we determine the extent of reliability of the data obtained from mixing one or another number of separate samples.

The structure of the root system of forest plants (mainly trees) is not the same. This is caused by the specific biological characteristics of the tree species and by conditions of habitat. We know that the same tree species, as a function of conditions of growth, develops a different root system.

The penetration depth and development of the root system determines the thickness of the soil layer drawn into the biological cycle. This fact must be considered when studying the dynamics of soil nutrients and determining the supply of mineral nutrients for plants. Our study should include, if not the entire root layer, at least that portion in which the main body of feeding roots is distributed. The content of one or another of the nutrients studied along with the usual quantitative expression in mg/100 ha or per 1 kg of soil, should be calculated in supply of a given nutrient in the root layer or in a principal part of it, by unit of area (1 ha). In studies there were cases when the nutrient content in their usual expression (mg/100 ha) was almost the same with different soil groups and soils of sharply different productive capacity. If we compute the total nutrients in available form for the main portion of the root layer of soil, we see a sharp difference in the plant nutrient content on the given soils, caused by a varyin thickness of the layer drawn into the biological cycle.

Let us show this by example. In Table 2 we have data on the amount of available P_2O_5 and K_2O in the soils of spruce growing in the fores steppe and taiga zones. Studies were made in the forested steppe zone on 27- and 60-year ol spruce plantations found on leached fine clay loam chernozem of Mokhovskiy lumber camp, Orlovskaya Oblast', developed on loess-like clay loam; in the taiga zone studies were made on 110- and 130-year old spruce on podzolic ar peat-humic gleyish soils developed on calcareo moraine (Khorovskiy lumber camp, Vologodskaya Oblast').

The leached chernozems of Mokhovskiy lum ber camp were characterized by a water and a regime very favorable to vegetation. Long seasonal periods of excessive surface moistur which is a principal factor limiting the productive capacity of these forest stands, were typic of taiga soils, particularly the peat-humic.

Sharply different conditions in the growth of these spruce are responsible for the different productive capacity of the forest stands, the structure of their root systems and the thickne of the root layer of soil. On the leached chern zems of the forested steppe, spruce plantation have a site quality class of I - Ia, with a deepl penetrating, well developed root system. The spruce of the taiga zone have a site quality cla of IV, with a surface root distribution. The roots penetrate somewhat deeper on the podzol soils occupying the relatively higher parts of t relief with excellent aeration and moisture con ditions as compared with the peat-humic soils; the productive capacity of these podzol soils is somewhat higher. In computing the available nutrient contents the following thicknesses of t root layer of soil were used: for chernozem, 90 cm; for peat-humic gleyish soil, 30 cm; anc for podzolic soil, 40 cm.[2]

The leached chernozems of the forested steppe are characterized by a low content of available phosphoric acid — from 3.0-6.6 mg 100 g of soil. Only the forest litters are characterized by a high content of P_2O_5. In the soi profile the distribution of P_2O_5 is uniform. In the soil of a 27-year old spruce we note the smallest amount of P_2O_5 in the upper 10 cm la which may be associated with the adaptation of the main mass of feeding roots to these depths and with their consumption of P_2O_5. In the soi of a 60-year old spruce below 40 cm, the cont

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[2] To compute the nutrient contents we took a layer soil with 90%-95% of small roots.

Table 2

Content of available phosphorus and potassium in soils of the forested steppe and taiga zone

Leached chernozem					Peat-humic gleyish soil			Podzolic soil		
Depth, cm	27-yr-old spruce		60-yr-old spruce		Depth, cm	130-yr-old spruce		Depth, cm	110-yr-old spruce	
	Mg/ 100 ha	Kg/ 1 ha	Mg/ 100 ha	Kg/ 1 ha		Mg/ 100 ha	Kg/ 1 ha		Mg/ 100 ha	Kg/ 1 ha
					P_2O_5					
Litter	34.0	7	34.0	5	0—5 (litter)	8.7	6	0—5 (litter)	11.0	8
0—10	3.6	32	6.4	54	5—10	6.5	5	5—15	1.0	14
10—20	4.1	37	4.1	37	10—20	6.5	24	15—25	9.0	126
20—30	4.5	45	3.7	39	20—30	10.0	60	25—35	9.0	126
30—40	4.4	49	4.9	52	30—40	18.0	234	35—40	10.0	75
40—50	5.0	57	3.0	33	40—50	18.0	324	40—50	10.0	170
50—60	5.0	57	3.5	38	0—30		95	0—40		349
60—70	6.6	76	4.0	44	0—50		653	0—50		519
70—80	6.0	72	4.0	46						
80—90	5.0	60	3.5	40						
Total		492		388						
					K_2O					
Litter	108	23	121	18	0—5 (litter)	190	142	0—5 (litter)	164	123
0—10	23	202	24	202	5—10	74	55	5—15	7	98
10—20	11	98	13	118	10—20	74	274	15—25	6	84
20—30	13	130	14	147	20—30	13	78	25—35	6	84
30—40	13	146	10	106	30—40	15	195	35—40	18	135
40—50	13	148	10	109	40—50	15	270	40—50	18	306
50—60	12	138	11	123	0—30		549	0—40		524
60—70	12	138	11	123	0—50		1014	0—50		830
70—80	11	126	12	138						
80—90	11	126	12	138						
Total		1275		1222						

$_2O_5$ as compared with the soil of a young uce is somewhat less; evidently, this is ociated with the composition of the parent erial.

The litters are considerably poorer in taiga ls and the content in the litters of P_2O_5 does differ from that in the mineral horizons. viously, this is associated with a maximum uration of the litter with feeding roots and by t consumption of P_2O_5, and also with leaching he lower lying horizons. In the peat-humic we see a noticeable increase in the content $_2O_5$ in the layer below 30 cm, i.e., the er not actually being utilized by roots. In zolic soil, except the impoverished A_2 hori- (depth of 5-15 cm) P_2O_5 distribution is very orm. Compared with the leached cherno- ns the taiga soils contain 1-1/2 to 2 times re available P_2O_5 (computing per unit of soil ght).

A different picture emerges when we examine the results of determining available phosphoric acid, expressed as available phosphoric acid contents in the root layer of soil. The leached chernozem of 27-year old spruce has the greatest content of available phosphoric acid equal to those distributed in the root layer of soil. The P_2O_5 content in chernozem under 60-year old spruce is approximately 20% less than in the 27-year old spruce. The P_2O_5 content in podzolic soil is only a little less than in chernozem of 60-year old spruce. From this we see that the quantity of available P_2O_5 in the root layer of soil which amounts to 350 kg/1 ha, could guarantee the normal growth of a forest stand having a considerably higher productive capacity than is observed on podzol soil.

Peat-humic gleyish soil is characterized by the lowest content of available P_2O_5 — 95 kg/ha. However, there is enough of it for the growth of a forest stand with a site quality class of IV and possibly for a higher productive capacity if the vegetative growth on peat-humic gleyish soils were not limited by unfavorable water-air properties that retard the growth of root systems during excessive moisture periods in these soils. The soil layer found directly below the root layer contains very large amounts of P_2O_5. Consequently, we might expect that with a slight lowering of the ground-water level, which prevents root penetration and root utilization of soil layers below 30 cm, this layer will become available to spruce roots and will be drawn into the biological cycle. There is enough available P_2O_5 in a half-meter layer of peat-humic soil to provide for the growth of a forest stand of the highest productive capacity.

The taiga soils are richer than chernozem in the amount of available potassium, expressed in mg/100 ha. There is more potassium in horizons predominant in organic matter and in the mineral layer, particularly in the illuvial horizon of podzolic soils. We see that the podzolic horizon is noticeably poor in available potassium. In chernozems, except the upper 10 cm layer, where there is twice as much potassium than in the lower lying horizons, potassium content is uniform. Amounts of available potassium in the root layer of chernozems and taiga soils are far higher than phosphoric acid contents and seem to fully guarantee the normal vegetative growth.

Amounts of phosphoric acid and available potassium in the root layer of chernozems are considerably higher than in taiga soils, whereas when expressing the results of analysis in mg/100 ha we see a reverse picture, which distorts the actual supply for vegetative growth on the soils studied.

The problems discussed in this article are not new. The reliability of data obtained from studying soil fertility, thickness of layer which must be subjected to investigations, and methods for expressing the results of work, determine to a great extent the value of the studies made but are not always sufficiently considered. This is why we deemed it useful to direct the reader's attention to them.

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HOSPHOROUS CONTENT IN CRIMEAN STEPPE SOILS

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A change in soil-forming processes under influence of human activity is noted in the rks of Vil'yams (1), Sokolovskiy (5), Zonn (3), urin (7), Frantsesson (8), Kochkin (4) and ny others. From century-old use, soil inges, as compared with virgin soil, both in rphological structure of soil profile and in ysicochemical and biological properties.

In this article we shall briefly deal with the blem of the influence of agricultural human ivity on the change in phosphoric acid content l its distribution by horizons in Crimean ppe soils.

Agriculture on the Crimean peninsula began be developed very early. The principal occu- ion of the population was cattle-breeding and mitive farming. Long (estimated at a thou- d years) unsystematic cattle grazing in the imean steppes and improper soil cultivation ler a three-field agricultural system brought out certain changes in the structure of the soil ofile. Analyses have revealed a peculiar ntitative distribution of phosphorus in the l layer of the Crimean steppe. Ordinarily, re is more P_2O_5 in the upper part of the soil ofile than in the lower. "Phosphorous enrich- nt of the uppermost soil horizons — Shmuk (9) nted out — and the relative impoverishment he lower-lying layers by the uppermost hori- s is explained by the activity of the root sys- n of plants." Plants by their own roots ract the phosphorus from the deeper horizons ether with other nutrients and deposit it as anic compounds on the surface and on the er part of the soil layer. We do not see such attern of phosphorous distribution in the mean steppe soils.

There is 0.09%-0.13% P_2O_5 in the soil- ming parent material (loess-like clay) and 8%-0.11% P_2O_5 (Table 1) in the plowed layer old plowed soils.

The absence of phosphorous accumulation and n phosphorous deficiency of upper soil horizons he Crimean steppe, are obviously associated with human activity, i.e., with phosphorous depletion by cultivated crop yields — mainly grain crops, and also by mowing or grazing grasses.

An increased phosphorous content is seen only in the center of the profile of chestnut group soils, formed in the Prisivashskaya lowland in areas from 3-5 to 25-30 m above sea level. Phosphorus in this part of the profile is accumulated in the same way as in the upper part, owing to phosphorous accumulation by plant roots from soil-forming parent material, but only in far lesser amounts.

The quantitative accumulation of phosphorus in the center of the profile of these soils exceeds the phosphorous contents of the upper parts.

An increased phosphorous content in the center of the profile of chestnut soils as compared with the phosphorous content in the upper part, should be explained not by a more intensive phosphorous accumulation but by a lesser leaching and removal, than from the upper horizons.

In the center of the profile of southern chernozems, developed in the Central Crimean steppe, phosphorous accumulation is not observed. This gives us a right to suppose that the Central Steppe of the Crimean peninsula has been plowed far earlier than the Prisivash'ye area; as a result the soils here are even poorer in phosphorus.

In the dark-chestnut weakly solonetzic soils in the center of the soil layer, the phosphorous content is 0.14% P_2O_5; it is possible that there was no lesser amount of phosphorus (but even perhaps a greater amount) in the upper layer of these soils before they were plowed. Century-old carnivorous management of land use, without use of fertilizers, led to phosphorous impoverishment of the upper part of the soil profile. This assumption has been confirmed by data on the phosphorous content in continuously fallow soils, or in soils long in disuse. This area is situated within the confines of the Crimean Oblast' Group Agricultural Experimental Station.

Table 1

Total content of humus and P_2O_5 on absolutely dry soil, in %

Soil	Depth, cm	Total Content	
		Humus	P_2O_5
Chernozem, southern, weakly humic, Krasnogvardeyskiy rayon	0—10	2.9	0.10
	20—30	2.7	0.09
	35—45	2.2	0.11
	60—70	1.1	0.09
	90—100	0.5	0.09
	140—150	—	0.09
Dark-Chestnut, weakly solonetzic, Azovskiy rayon	2—12	3.0	0.10
	22—32	2.6	0.12
	38—48	2.1	0.13
	50—60	1.2	0.14
	90—100	0.8	0.13
	190—200	—	0.11
Dark-Chestnut, medium solonetzic, Sovetskiy rayon	0—10	2.6	0.11
	21—31	2.1	0.10
	35—45	1.6	0.13
	70—80	0.7	0.12
	125—135	—	0.12
Chestnut, medium solonetzic, Kirovskiy rayon	0—10	2.4	0.08
	20—30	1.8	0.10
	40—50	1.2	0.12
	60—70	0.5	0.11
	92—102	0.4	0.12
Meadow-chestnut, strongly solonetzic, Azovskiy rayon	0—10	2.2	0.10
	20—30	1.8	0.10
	45—55	1.2	0.11
	65—75	0.5	0.13
	90—100	0.3	0.12
	145—155	—	0.13

Laboratory analysis data on soil samples of southern chernozem in this area are given in Table 2. Up to 4.5% humus was accumulated in the 0-10 cm layer during extensive disuse of this soil, while the amount of phosphorus increased to 0.13% as opposed to 0.10% P_2O_5 found in the same, but plowed, chernozems (Table 2).

This is also confirmed by data (Table 2) obtained from analyzing samples of deep solonetz, formed at a 3-5 m above sea level on an area that had been plowed several years previously. Here we see an increase of P_2O_5 from 0.09% in the soil-forming parent material to 0.13% in the upper half-meter of soil layer (except the strongly solodi 0-10 cm layer).

As a result of a noticeable removal of phosphorus from the soils of the Crimean steppe, field crops now react positively to application of phosphorous fertilizers; thus, in experiments by Tulin and Sevast'yanova (6) an increase (2.4-4.3 cntr/ha or 10.2%-18.2% fron a control experiment) in grain yield of winter wheat was obtained by adding superphosphate fertilizer by various means and in various amounts into dark-chestnut weakly solonetzic soils of the Dzhankoyskiy rayon.

Conclusions

1. As a result of agricultural human activity the upper horizons of soil are considerably deficient in phosphorus, which evidently was removed by harvesting cultivated crops and wild-growing grasses.

Table 2

Total content of humus and phosphorus on absolutely dry soil, in %

Soil	Depth, cm	Total Content	
		Humus	P_2O_5
Chernozem, southern, weakly humic, Virgin strip, Krasnogvardeyskiy rayon[a]	0—5	5.5	0.14
	5—10	3.6	0.11
	10—15	3.4	0.11
	20—25	3.0	0.11
	45—50	1.6	0.12
	70—80	0.8	0.11
	150—160	—	0.12
Deep solonetzic. Azovskiy rayon	0—10	2.2	0.11
	22—32	1.5	0.13
	38—48	1.0	0.13
	55—65	0.5	0.12
	90—100	—	0.12
	150—160	—	0.11
	190—200	—	0.09

[a] Data of V. P. Gusev and V. T. Kolesnichenko (2).

2. To increase the fertility of Crimean ppe soils, we deem it necessary to apply osphorous fertilizers, along with employing er methods.

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EFFECT OF VARIOUS CULTIVATION METHODS ON THE WATER REGIME OF CHERNOZEM SOILS[1]

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This report discusses several results of studying the effect of the water regime of soils by the different methods used to cultivate virgin lands. Studies were conducted in 1954-1956 in the forested steppe zone of Kokchetavskaya Oblast' (Northern Kazakhstan) on fields of kolkhozes "Red Army Man" and "30 Years VLKSM," Zerendinskiy rayon.

The soils are fine clay loam ordinary chernozem. Thickness of humus horizon (A + B) is 45-55 cm. Physical clay content (particle diameters smaller than 0.01 mm) is 54% in the humus horizon and 60% in the soil-forming parent material. The water-physical characteristics of these soils are given in Table 1.

We should note that, as bulk density increases with depth, the percent of moisture available to plants decreases. If in the upper humus horizon (0-50 cm) there is one and one-half times more available moisture than in corresponding layers of lower-lying horizons, twice as much moisture will be found in the uppermost 30 cm layer than in the horizons of soil-forming parent material.

A specific characteristic of the climatic conditions of Kokchetavskaya Oblast' is the unequal distribution of precipitation by seasons of the year. Most precipitation occurs in the summer. Average annual precipitation is 330 mm. There was 196 mm precipitation in the 1954 vegetative period; the largest percentage was in August — 90 mm. There was even more precipitation (259 mm) for the same period in 1956. At the same time agricultural crops often suffered from moisture deficiency, since in May and June there was frequently very little rainfall. Thus, from May 1 — August 15, 1955, there was only 56 mm precipitation with 9 mm in May and 13 mm in June.

One might suppose that fallow cultivation contributes to moisture accumulation in the soil. However, under Northern Kazakhstan conditions during a vegetative period (May — August) fallow fields in moist years lost almost all precipitation occurring during this period to evaporation and during relatively dry years lost all precipitation and a certain percentage of soil moisture from the spring season. Thus, from June 15 — August 15, 1954, there was 89 mm precipitation. During this time moisture content in the soil increased by only 14 mm. Seventy-five mm or 84% of precipitation evaporated. From August 15 — October 1 (when the ground began to freeze) there was 96 mm of precipitation. Only 54 mm had been accumulated by the soil. Even in the fall a little more than 50% precipitation is accumulated. In the dry year 1955, from June 15 — August 15 there was 21 mm precipitation, and moisture content in the soil decreased 34 mm. Thus, fallow fields in the summer may lose large amounts of moisture that cannot be made productive.

We cannot assume that the problem of moisture accumulation on fallow fields at the expense of the snow cover, has been adequately explained. Our data show that intake of melted snow is a function of the extent of soil moisture at the time the ground begins to freeze. The more moisture the soil has under the snow cove the less are the amounts of melted snow absorb by the soil. Table 2 gives data on spring and fall soil moisture contents in fallow fields of cultivated virgin lands.

On Field No. 1 the upper 50 cm soil layer before freezing was saturated at field moisture capacity. There was also much moisture in the lower lying layers, although less than field moisture capacity. Spring soil moisture content on this field was only 23 mm more than fall moisture content. If we consider that froze soils with moisture exceeding field moisture capacity do not have any appreciable water permeability, and that snow leaves the fields before the upper soil layers thaw out, then we have to admit that almost all the melted snow in this

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[1] Reported at the First Delegates' Session of Soil Scientists, May 1958.

Table 1

Water-physical indicators of ordinary chernozem

Depth, cm	Particle density	Bulk density	Maximum hygro-scopicity	Moisture at permanent wilting	Field moisture capacity	Total porosity, %
	g/cm³		% by volume			
0—10	2.60	0.97	10.8	14.0	36.7	62.7
10—20	2.60	1.04	11.5	14.5	36.5	60.0
20—30	2.65	1.15	12.2	16.3	36.0	56.6
30—40	—	—	—	17.8	34.2	—
40—50	2.70	1.27	—	18.4	33.5	53.0
50—60	—	—	13.6	20.5	33.1	—
60—70	—	—	—	20.4	33.6	—
70—80	2.72	1.38	13.1	20.4	33.7	49.3
80—90	—	—	—	21.8	33.6	—
90—100	—	1.45	12.6	22.9	34.0	—
100—110	—	—	—	21.3	33.8	—
110—120	2.75	1.51	13.00	21.9	33.2	45.1
120—130	—	—	—	22.0	34.2	—
130—140	—	1.57	14.4	22.0	34.8	—
140—150	2.76	1.59	—	22.5	35.0	44.1

Table 2

Soil moisture content, mm

Depth, cm	Field No. 1		Field No. 2	
	10-1-54	5-2-55	10-1-55	5-3-56
0—50	179	194	137	181
50—100	153	159	130	167
100—150	153	155	147	153

Table 3

Change in soil moisture during vegetative period[a]

Depth, cm	Moisture content, mm						
	At field moist. capacity	May 5	May 11	June 3	June 27	July 1	July 27
0—50	177/96	194/113	180/99	168/87	103/22	87/6	110/29
50—100	168/62	158/52	170/64	173/67	151/45	144/38	133/27
100—150	171/61	155/45	159/49	—	151/41	153/43	158/48

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[a] Numerator is the total moisture content; denominator is the available moisture.

e either flows away or evaporates.

We see a different picture on Field No. 2. 1955 the soil under snow was left in an unsaturated state. By spring, soil moisture content increased 87 mm. When working on snow retention on fallow fields we must consider soil moisture at the time the ground is freezing. If soil moisture of the upper layers reaches field moisture capacity when the soil freezes, snow retention, from the moisture accumulation standpoint, will be little effective in this case. Fallow fields accumulate the precipitation in two periods — fall and winter. It is evident that in some cases soil on fallow fields will freeze when moisture of the upper layers of soil profiles correspond to field moisture capacity.

Under Northern Kazakhstan conditions, the moisture cycle of soil-plant-above air, the grain-crops will utilize the moisture in a one and one-half meter layer of soil. Ordinarily, we might assume that the more moisture accumulated in this layer the higher the yields. But we observe cases under natural conditions when this situation cannot be considered reliable. As an example, let us look at the data in Table 3 on the change in soil moisture for the 1955 growing period on a field of spring wheat sown from fallow cultivated virgin land.

In the spring, the available soil moisture content with the root layer exceeded 200 mm and approached the amount at field moisture capacity. The 1955 growing period was characterized by extreme drought. Despite the fact that we had the highest possible amount of available soil moisture at the start of the growing season, spring wheat was subject to an extremely low moisture supply. Even during this exceptionally dry year large amounts of available moisture in the root zone were not utilized. Moisture was used in transpiration and evaporation only from a meter of soil layer. In the 0-50 cm layer all available moisture was used by August 1, while in the 50-100 cm layer a little more than 50% of moisture was used by the end of the growing period. The moisture in the 100-150 cm layer during a whole growing period did not fall below 90% of field moisture capacity.

This is explained by the fact that when the secondary root system was formed, the surface soil layer within the tillering zone was dry. As a result the secondary roots were not able to form and the primary roots proved to be clearly incapable of using the small amount of available moisture in the soil. The rainfall at the end of June was responsible for the formation of secondary roots, but these roots were unable to penetrate the already relatively dry layer to the lower-lying moist layers. The secondary roots remained in the soil layer nearest the surface and were able to utilize only the small amount of moisture from precipitation, as has already been mentioned. Inasmuch as the basic amount of moisture enters the plant through secondary roots, it becomes evident that, despite most severe drought, large amounts of moisture within the root zone were not utilized. Consequently, the contents of available moisture in the soil may be used only when the plant's secondary root system is formed at the opportune moment. Moisture flow in a liquid state in ordinary fine clay loam chernozems toward the evaporating or root horizon, can occur only when soil moisture is 80% of field moisture capacity. When it is below this amount, moisture absorption by plants from different horizons occurs only when the root hairs penetrate the horizons. And from a depth of one meter, when moisture is less than 0.9 of field moisture capacity, soil moisture cannot move upward in a liquid state.

Hence, there is a need to study the reaction on formation conditions of the secondary roots of grain crops. As our studies have shown, the creation of a relatively compacted layer in the plowed layer within the tillering zone contributes to a vigorous formation of secondary roots.

In 1956, after sowing spring wheat a part of the field was rolled with smooth water-filled rollers (ZKVG 1.4). As a result of rolling, an intermediate compaction was formed in the plowed layer. (Table 4).

Even within the moisture deficient zone, spring moisture contents always assured germination. But often when they tillered, and, consequently, when secondary roots were formed, the tillering nodes appeared in the already dry soil and secondary roots were not formed.

The compacted layer formed by rolling is responsible for the favorable redistribution of soil moisture. Total moisture consumption (evaporation and transpiration) on rolled and non-rolled strips was approximately the same and amounted to 339 and 331 mm, respectively, while moisture content in the plowed layer for an entire growing period on a rolled strip was higher (Table 5).

It is quite obvious that a plant having a more developed root system will also be more productive. If a yield of 12.5 cntr/ha were obtaine from a non-rolled strip the yield from a rolled strip would be 14.9 cntr/ha.

Thus, the presence in the plowed layer of a relatively compacted layer is a necessary condition for the growth and development of grain crops.

If the growth and development conditions of grain crops are more favorable with a relatively compacted structure of the plowed layer than with a friable structure we have a right to expect a somewhat higher yield from a shallow-plowed stubble than from a field deeply plowed in the fall. Our observations over a three-year period show that on ordinary chernozems of Northern Kazakhstan spring wheat yields from a shallow-plowed stubble field are either equal to or somewhat higher than yields from a fall-plowed field. A marked difference in plowed layer compaction on the fall-plowed field and on shallow-plowed stubble field is still seen by sowing time.

The moisture difference remains wherever there is snow retention (Table 6). In 1954 ther was snow retention and in the spring we noted a somewhat larger moisture content on the fiel plowed in the fall. In 1955 and 1956, snow was not retained. In this case there were larger moisture contents from the shallow-plowed stubble field.

Table 4

Effect of rolling on soil compaction in plowed layer and root growth

Depth, cm	Bulk density, g/cm³		Root wt. in g per 1 m² during the boot stage in 10-20 cm layer	
	Without rolling	By rolling	Without rolling	By rolling
0—5	0.90	0.97	80	104
5—10	0.95	1.06		
10—15	0.95	1.03	57	82
15—20	0.99	1.00		

Table 5

Effect of rolling on the moisture content of the plowed layer

Plot	Moisture content, mm, in 0-20 cm soil layer						
	May 17	June 6	June 20	July 4	July 31	Aug. 10	Aug. 23
Rolled	71.8	60.3	58.2	42.0	49.6	37.3	29.7
Non-rolled	65.8	55.2	54.6	41.7	45.0	33.4	29.6

Table 6

Moisture contents, mm[a]

Depth, cm	Spring 1954		Spring 1955		1956			
					Fd. plowed in fall		Stubble	
	Field plowed in fall	Stubble	Field plowed in fall	Stubble	May 14	Aug. 20	May 14	Aug. 20
0—50	143	143	142	165	354	92	167	97
	59	59	61	84	73	11	87	16
50—100	134	131	136	163	152	138	167	137
	43	40	30	57	46	32	61	31
100—150	146	137	134	134	161	152	158	154
	47	38	24	24	51	42	48	44

[a] Numerator is the total content; denominator is the available moisture.

The effect of a relative compaction of plowed er on a spring wheat harvest is most clear- seen in the 1956 experiment. Total moisture ısumption determined by water balance from fall-plowed field and from the shallowed-wed stubble field was approximately the ne and equalled 336 and 354 mm respective- But if we consider that large amounts of ilable moisture in the 50-150 cm layer were utilized by the end of the growing period we uld admit that spring wheat in both experints did not experience moisture deficiency. Plants were under similar moisture supply conditions, but under different soil compaction conditions. A relatively compacted plowed layer from shallow-plowed stubble field proved more favorable to plants than the friable structure from the fall-plowed field. The yield from the shallow-plowed stubble field (19.4 cntr/ha) was 2.5 cntr/ha higher than the yield from the fall-plowed field.

The experiment shows that we can obtain very different yields when we cultivate virgin land. These variations in yields depend mainly on the methods used to cultivate virgin soil. Most agricultural specialists are of the opinion that we should till or plow virgin lands with plows and coulters. Moreover, we must see to it that the sod is fixed as best possible in the lower part of the plowed layer. T. S. Mal'tsev expressed a different opinion. According to him, cultivation of virgin land should consist of sod disking and deep plowing without moldboard.

In 1955, virgin soil was cultivated according to type of fallow as follows: 1) usual plowing and 2) disking without turning over the soil. Moisture content decreased in both of these experiments during the course of a year. After 60 summer days, soil moisture losses from deep plowing were 550 m^3/ha and from usual plowing, 380 m^3/ha. Moisture contents were increased from the melted snow and early spring precipitation by 88 mm with deep plowing and by 103 mm with usual plowing.

At the beginning of the 1956 growing period (Table 7) soil moisture contents in the root zone from experimental treatments corresponded to field moisture capacity.

Table 7

Moisture contents at beginning and end of vegetative period[a]

Depth, cm	May 3		August 22	
	Deep plowing	Usual tillage	Deep plowing	Usual tillage
0—50	$\frac{181}{103}$	$\frac{212}{131}$	$\frac{90}{12}$	$\frac{93}{12}$
50—100	$\frac{167}{61}$	$\frac{162}{56}$	$\frac{120}{14}$	$\frac{114}{8}$
100—150	$\frac{153}{43}$	$\frac{161}{51}$	$\frac{160}{50}$	$\frac{158}{48}$

By the end of the growing period practically all available moisture had been used up from a meter of soil layer. The spring wheat yield with usual plowing was 2.6 cntr/ha higher than with deep plowing. (18.8 and 16.2 cntr/ha) with total moisture evaporation almost equal (398 and 424 mm.).

Conclusions

1. Moisture loss, rather than moisture accumulation in the soil takes place on fallow fields during the summer. Moisture accumulates from fall-winter spring precipitation; moreover, the more moisture in the soil when the ground begins to freeze the less the soil stores melted snow. There may be cases when all melted snow either flows down the slope or evaporates.

2. On well-structured ordinary chernozems, moisture movement in a liquid state to the evaporating or root horizon ceases when soil moisture is 0.8 of field moisture capacity. Below this limit moisture consumption from different horizons of the soil profile occurs only if, by chance, the root hairs penetrate the horizons.

3. The presence in the soil of the highest possible moisture content does not as yet decide the crop yield. The use of available moisture depends on how opportunely plants form a secondary root system. When secondary roots are formed, grain crops utilize all available moisture from a one and one-half meter layer of soil: otherwise, even under dry years, large amounts of available moisture in the root zone will not be utilized by the end of the growing period.

4. The notion of most vigorous growth of root system of grain crops in well-loosene soil cannot be assumed to be reliable. On the contrary, the root system is developed better in more compacted soil.

5. The usual type of plowing should remain the principal method of cultivating virgin lands on ordinary chernozems of Kokchetavskaya Oblast'. Deep plowing without moldboard, from the standpoint of creating a favorable water regime and physical conditions, is not preferable to usual plowing.

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OVEMENT OF VAPOR MOISTURE IN UPPER SOIL LAYERS

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We note in upper soil layers a most intensive evelopment of heat and moisture transfer both the form of liquid and vapor.

Lebedev (1, 2) was the first to study vapor- oisture movement in the soil under natural onditions. Other studies were concerned pri- arily with vapor moisture movement in soil mples and in soil models.

Our objective was to study the moisture ovement processes in the soil under field onditions and to examine the patterns and rate these processes, in order to regulate them d to attain high crop yields. The results of r studies on heat and moisture transfer in e soil, obtained at the Krymskaya Experiment ation for Melioration, have been published in earlier paper (5). We will show the results studying patterns of diurnal vapor-moisture ovement.

To understand fully moisture movement in por form, we must have data on the temper- ure of the soil skeleton and on air parameters soil pores at various depths for several diur- l cycles. Methods used to obtain these data ve been described elsewhere (5); therefore, will be concerned only with the method used measure parameters of air in soil pores.

We used copper-constantan thermocouples th a 0.15 mm wire diameter to measure the mperature of air in the pore. Working junc- ons of thermocouples were shielded from ming into contact with soil by ampoules con- ructed from a metallic screen (grid). We ose fairly small size ampoules to model the il pore. Each ampoule was secured to a nall glass receptacle. The water could be ought out of the receptacle towards the junc- on by cotton threads and thus constantly mois- n the junction. We eliminated the effect of ter evaporating directly out of the recepta- by tightly fitting the cotton threads (of the ck) into the outlet of the receptacle.

This arrangement of thermocouple junctions enabled us to measure the temperature difference between the dry-bulb thermometer (t_c) and wet-bulb thermometer (t_m) of porous soil air at various depths, to determine its saturation at these depths, and the saturation change during a 24-hour period, and to establish the condensation possibility of the water vapors in the pore air.

This thermocouple arrangement was set up on a cultivated experimental field at depths 5, 10, 15, 25, 40 and 60 cm from the surface; hourly measurements were taken for a period of several days.

Additional t_c and t_m measurements of air above the soil were taken with an Assmann psychrometer 1 cm from the soil surface in order to compare the psychrometer readings and to show the relationship of porous soil air to air above the soil surface. In addition, we measured the temperature of soil particles at all depths given. The experimental data are given in diagrams and tables.

The curve of changing psychrometer differences in air temperatures of the surface soil layer, constructed from thermopsychrometer readings coincides with the curve of changing psychrometer differences in atmospheric air constructed from Assmann psychrometer readings. The data show that a change in the unsaturated state of porous soil air gradually disappears with depth, and over a 24-hour period. At night for pore air of soil surface layers $t_c < t_m$, which apparently, can be explained by vapor condensation.

To clarify the processes of vapor transfer in the surface soil layers during a period of 24 hours, we further processed the experimental data, and, using Shprung's formula, computed the partial vapor pressure at different soil depths:

$$P_n = P_M - 0.504 \frac{B}{760} (t_c - t_m)$$

where: P_M = saturated vapor pressure using the wet-bulb thermometer temperature in mm of mercury; B = barometric pressure in mm of mercury.

We also computed the relative humidity of pore air and the nonisothermic vapor transfer potential (effusion) in the soil microcapillaries:

$$\theta = \frac{P_n}{\sqrt{T}}$$

For comparison purposes, all parameters of above-soil air were also calculated. Table 1 gives data for one 24-hour period; from these data we see that at a depth of 25 cm soil air remains completely saturated for 24 hours. Partial vapor pressure and the nonisothermic vapor transfer potential

$$\theta = \frac{P_n}{\sqrt{T}}$$

in each soil layer varies during the 24-hour period approximately according to sinusoidal law. The ascillation of amplitudes decrease with depth and changes with time. We do not see the maximum oscillation amplitude on the soil surface but at a depth of 5 cm from the surface. By magnitude and direction of parameter gradients we can determine the direction and rate of vapor transfer in the soil for a 24-hour period, i. e., we can get a complete picture of diurnal patterns of vapor transfer in the soil.

At night and in the morning when the soil surface is cooled and partial vapor pressure is greater below the surface than at the surface (Table 1), vapor transfer occurs within the soil surface. During the day and in the evening vapor transfer occurs in two directions; above and below the layer having the maximum partial pressure. Inasmuch as the surface layers are more friable and the partial pressure gradients and vapor transfer potential in the 0-5 cm layer from the surface, are several times greater than the gradients and potential in the deeper layers, it stands to reason that there will be a more intensive transfer of vapor towards the soil surface and into the air above the soil.

This non-stationary process of vapor transfer in the soil affects the moisture content of soil-pore air within the layers of soil and in different ways alters the moisture content of soil air during a 24-hour period. The diurnal changes in the relative humidity of soil-pore air at various depths can be seen in Figure 1. For purposes of comparison, we have plotted on this graph a corresponding curve showing the change in relative humidity of air above the soil (atmospheric air).

As we can see from Figure 1, $(x = 0)$ the relative humidity of air on the soil surface depends on, but is always higher than, atmospheric air humidity. As layer depth increases, pore-air humidity increases and below 25 cm it is permanently equal to 100%.

If we consider that evaporation occurs from the surface of soil particles where $\varphi < 100\%$, i. e., the air is unsaturated, we see that in this experiment moisture begins to evaporate in the soil at a depth of 5 cm in approximately 8 hours and 30 minutes, at a depth of 10 cm in 9 hours and 30 minutes, and at a depth of 15 cm in 12 hours, i. e., the evaporation zone moves deeper into the soil. Shift of the relative humidity minimums of porous air is also evidence of this. At night the soil-pore air in this experiment was completely saturated at all depths up to the very soil surface; therefore, if the temperature of the soil particles is lower than the temperature of pore air, vapor condensation on the particle surfaces is inevitable as is the moistening of soil surface layers by vapor transfer from deeper layers, where at night we find higher temperatures. As experiments have shown, moisture in the soil surface layers increased 2.5%-3% due to vapor condensation at night.

We found a linear relationship between time and change in depth of evaporation and condensation zones (Fig. 2).

The rate varies at which evaporation and condensation zones deepen (tangent of slope angle of straight lines to time axis). This coincides with the different length of time of warming and cooling soil over a 24-hour period.

From these experiments we can conclude that vapor moves at night within the soil towards the soil surface. Vapor moving from the warmer deeper soil layers encounters cold soil layers and condenses on its way, thus contributing to the moistening of surface layers and to temperature compensation according to depth by heat of the phase transformation. Some of the vapor, unable to be condensed, passes between the structured crumbs of the soil surface layers and escapes into the atmosphere.

Intensive moisture evaporation begins at sunrise and when the soil begins to be warmed. The porous air of the surface layer becomes unsaturated, the evaporation zone gradually deepens, and moisture accumulated during the cooling period evaporates into the air surrounding the structured soil units and is carried off by natural convection currents being developed in the 0-5 cm layer. Some of the vapor moisture may move into the lower-lying soil layers. By increasing the humidity of the pore air to 100% (φ) and by encountering cold layers, water vapor will be condensed and will increase the moisture content of soil somewhat at depths of 10 to 30 cm. The evaporation zone does not go more than 25 cm below the soil surface. When soil surface temperature begins to drop, this

Table 1

Diurnal change in partial pressure, nonisothermic vapor transfer potential and in relative humidity of soil-pore air

Time (24-hr. period)	Atmospheric air 1 cm from soil surface			$x=0$			$x=5$			$x=10$			$x=15$			$x=25$		
τ	P_n	θ_n	φ	P_n	θ	φ	P_n	θ	φ	P_n	θ	φ	P_n	θ	φ	P_n	θ	φ
8—45	—	—	—	16.48	0.95	87.0	16.53	0.97	100.0	17.78	1.04	100.0	19.24	1.12	100.0	19.83	1.16	100.0
9—20	—	—	—	—	—	—	17.69	1.03	99.1	17.70	1.03	100.0	19.14	1.12	100.0	19.83	1.16	100.0
11—35	—	—	—	18.14	1.04	83.0	19.96	1.16	96.5	18.40	1.07	98.8	19.29	1.12	100.0	20.08	1.17	100.0
12—45	—	—	—	—	—	—	24.35	1.40	95.5	20.80	1.17	98.3	20.72	1.20	100.0	20.95	1.22	100.0
13—35	12.81	0.73	66.3	20.01	1.14	80.0	26.90	1.55	96.4	21.30	1.23	97.5	20.25	1.18	98.5	20.70	1.20	100.0
14—45	12.74	0.73	67.5	19.73	1.23	83.0	28.97	1.66	97.5	22.53	1.30	99.0	20.37	1.18	98.5	20.70	1.20	100.0
15—55	12.77	0.73	66.7	19.44	1.11	84.4	28.88	1.66	94.0	23.59	1.36	98.5	20.83	1.21	98.3	20.58	1.20	100.0
16—50	13.14	0.75	73.0	18.95	1.09	87.5	30.17	1.74	98.0	25.62	1.47	98.5	22.53	1.30	98.5	21.13	1.22	100.0
19—00	13.96	0.81	84.7	18.23	1.06	95.0	27.23	1.57	99.5	25.67	1.48	99.4	23.16	1.34	93.5	21.07	1.20	100.0
20—30	12.74	0.75	88.8	17.74	1.04	98.2	23.34	1.41	100.0	25.21	1.46	100.0	23.13	1.34	93.4	22.12	1.28	100.0
22—10	15.17	0.88	94.3	17.44	1.02	99.5	22.93	1.33	100.0	23.76	1.38	100.0	22.87	1.32	99.3	22.12	1.28	100.0
24—05	14.68	0.86	96.0	17.01	1.00	100.0	20.82	1.21	100.0	22.25	1.29	100.0	22.38	1.30	100.0	21.74	1.26	100.0
3—05	12.63	0.74	96.2	14.53	0.85	100.0	19.59	1.14	100.0	21.59	1.25	100.0	22.32	1.29	100.0	21.86	1.27	100.0
7—10	14.57	0.85	93.0	15.78	0.92	98.8	17.64	1.03	100.0	19.24	1.12	100.0	20.33	1.20	100.0	20.82	1.27	100.0
8—45	16.63	0.96	89.2	18.30	1.06	96.4	18.31	1.07	100.0	18.77	1.09	100.0	19.10	1.12	100.0	20.45	1.20	100.0

Note: Reference depth x in cm; P_n in mm of mercury; θ in mm of mercury x $T^{-\frac{1}{2}}$; φ - in %.

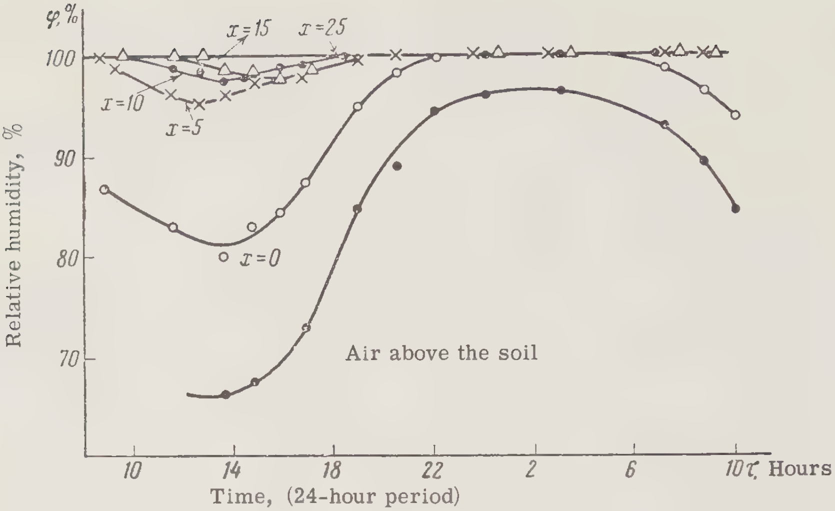

Fig. 1. - Change in the relative humidity of pore air of different soil layers for a 24-hour period.

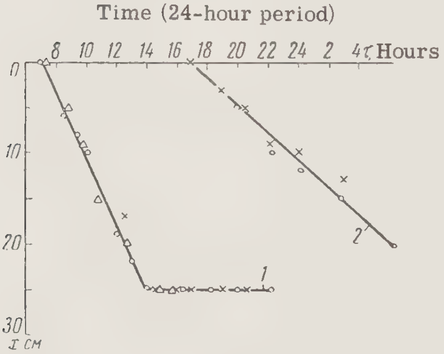

Fig. 2. - Distribution of the evaporation and condensation zone of moisture according to soil depth for a 24-hour period.

1 - Evaporation zone; 2 - condensation zone.

process ceases and a one-way vapor movement towards the soil surface takes place, which is observed to occur at night. This is how vapor moisture moves in the upper soil layers.

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IRST ALL-UNION CONFERENCE ON PROBLEMS OF OIL ZOOLOGY

I. S. GILYAROV

The first All-Union Conference on Soil Zoo- ogy was held December 25-29 at the Institute f Animal Morphology (Academy of Sciences, JSSR) in Moscow. The 115 delegates partici- ating were workers from scientific institutions nd teachers from 33 universities. Represented t the meeting were almost all the academies of ciences of the Union republics, three affiliates f the USSR Academy of Sciences, and a number f universities and agricultural institutes.

Riga, Dnepropetrovsk, Kiev, Kazan', Lenin- rad, and L'vov were represented by large roups of delegates. Among the participants ere 26 Ph. D's and 50 graduate students.

Ye. N. Mishustin, Associate Member of the cademy of Sciences, USSR, opened the con- erence, remarking that development of soil iology had in the past been one-sided: re- earch was devoted exclusively to the micro- iological processes occurring in soil, and nly a few investigations dealt with the role of nimals in soil formation. Mishustin empha- ized the need for a broad program of research n soil biology and the importance of soil zoology erein.

M. S. Gilyarov's (Moscow) report gave in- ight into the achievements and problems of oil invertebrate research. Soil invertebrates re studied both as factors in the improvement f natural soil fertility and as enemies of agri- ultural crops and forest plantations. The re- ort noted that, during the last ten years in the SSR and somewhat later elsewhere, soil zoolo- y has developed into a new and independent iological discipline.

A series of reports was devoted to evalua- on of the important role of invertebrates in oil formation. A. I. Zrazhevskiy (Kiev) dem- nstrated the contribution of invertebrates to the rtility of forest soils and suggested possible ays of controlling their useful activity. S. I. onomareva (Moscow) explained the role of arthworms in raising the fertility of sod- odzolic soils, supporting by means of chemical and microbiological analytical data the results of vegetative and field experiments. V. F. Nikolyuk (Tashkent) described the role of soil protozoa in the rhizosphere of cotton plants growing in irrigated sierozems. B. M. Mamayev (Moscow) traced the natural destruction of wood in deciduous forests by insects. The report of G. F. Kurcheva (Moscow) was of great interest. He demonstrated by ingenious field experiments that oak-forest litter containing a natural soil fauna decayed five times more intensely than when only fungi, bacteria, and actinomycetes were present. The effect of soil life upon the forest vegetation-supporting properties of soil was shown by the reports of I. I. Gordiyenko and V. I. Grimal'skiy (Kiev).

In many reports the effects of various methods of cultivation upon the soil fauna were analyzed.

S. G. Bobinskaya (Leningrad), M. A. Aleynikova (Kazan'), and E. E. Geshale (Omsk) produced data showing that application of the T. S. Mal'tsev cultivation system resulted in an increase in predatory ground beetles, which contributed to reduction in the number of wireworms and other pests.

Interesting data on the population dynamics and vertical migration of various ecological groups of invertebrates under grass-crop rotations were presented by V. K. Baluyev (Ivanova). The work of I. M. Pod'yakonova (Khar'kov) was devoted to the distribution of wireworms in the soil of fields under crop rotation. V. G. Shurovenkova (Kurgan) studied the effect of soil cultivation on harmful and useful soil fauna.

Zoologists from Dnepropetrovsk told of the formation of protozoa (L. V. Reyngard) and insect (A. G. Topchiyev) complexes in forest plantations of the steppe zone.

Information on the control of soil-inhabiting pests was provided by the report of B. V. Dobrovol'skiy (Moscow State University). He pointed out the undesirability of continuous application of poisons to the soil and the effectiveness of small local applications. A. V. Ponomarenko (Rostov) presented the results of experiments conducted over a long period involving banding with hexachlorane; and Z. A. Gushcho (Voronezh) told of experiments using various insecticides against soil pests.

A special session was devoted to the May beetle. Speakers Ya. I. Tsinovskiy (Riga), A. M. Shutyayev (Kursk), A. I. Vorontsov, and Ye. G. Mozolevskaya (construction specialist of Moscow Region), P. T. Korduba (L'vov), and others showed a high level of knowledge about soil(invertebrate complexes in a number of districts in various natural zones of the country. A. I. Cherepanov reported on study of the soil fauna of Western Siberia; I. V. Stebayev (Moscow) discussed fauna of the tundra region; and Ye. M. Chernova, T. S. Perel', and L. S. Kozlovskaya (Moscow) dealt with taiga-soil fauna.

An interesting series of reports on soil fauna of the Tatar SSR was presented by Kazan' zoologists M. M. Aleynikova, V. V. Izosimov, N. M. Utrobina and T. S. Izotova. A. F. Kryshtal' (Kiev) reported on his many years of studying soil fauna of the Dnieper region. Communications from Ya. V. Britskiy (L'vov), V. G. Dolin (Kiev), V. F. Paliy (L'vov) and others were devoted to the distribution in soils of individual groups of insects.

Riga zoologists (V. K. Eglitis, Dz. K. Kaktyuya, and others) conducted an especially thorough study of soil fauna in the Latvian SSR.

Surveys of individual groups of soil invertebrates were carried out throughout the country: on earthworms, by I. I. Malevich (Moscow); on diplopods, by I. Ye. Lokshina (Moscow); and on springtails, by A. P. Grinbergs (Riga).

The young investigators L. M. Semenova (Moscow) and I. A. Ovchinnikova (Leningrad) reported on the permeability of the shells of soil insects. The morphology of certain soil-insect larvae was analyzed by I. Kh. Sharova and N. P. Krivosheinaya (Moscow).

Notable amoung the methodological reports were: a study of soil amoebae, by Yu. G. Gel'tser (Moscow); a report on methods of estimating the number of nematodes, by E. L. Krall' (Tartu); and a paper on the rearing of click beetles, by A. S. Kosmachevskiy (Krasnodar).

Information on current and planned studies of soil fauna was presented at the meeting by A. T. Tulyaganov (Samarkand), D. N. Kobakhidze (Tbilisi) and others.

The foregoing account illustrates the variety of topics considered at the meeting as well as the achievements in the field of invertebrate studies.

On the other hand, the conference pointed up a number of deficiencies in current work on soil zoology. Above all, it became apparent that in various scientific centers work on this subject was being carried out without the necessary coordination; the choice of questions for study was often accidental; there were no unified methods of research. Therefore the resolution accepted by the conference requested that the study of living soil organisms as a factor in soil fertility and formation be isolated as an independent problem to be coordinated by the Academy of Sciences, USSR.

The conference asked the presidium of the Academy of Sciences, USSR, to make the Institute of Animal Morphology (the Laboratory of Soil Zoology) responsible for coordinated work on this problem.

Inadequate coordination of soil and zoology work was also observed in the majority of academies of sciences, in universities with biology and soil science faculties, in agricultural institutes, and in the Ukrainian Academy of Agricultural Sciences. The last possesses all the facilities necessary for organizing complex and effective studies of the soil-forming activity of soil fauna.

The conference drew special attention to the necessity of studying the effect of pest-control measures on useful soil-forming organisms (with emphasis on chemical methods).

Staffs of systematic zoologists and specialists on groups of soil-forming organisms must consider the situation. A body of soil zoologists must also be trained.

Departments of zoology and soil science of universities, pedagogical and agricultural institutes were advised to include subject matter dealing with soil organisms, and their soil-forming activity in departmental programs. It was also recommended that they provide similar subjects to the students for degree and course work.

It was also decided to prepare manuals on methods of soil-zoology research, keys to soil fauna, and guides to the mapping of data from soil-zoology surveys, etc.

The conference was the first organized step, both in the consolidation of the varied cross section of researchers working on soil fauna, and in the direction of work towards the solution of basic problems confronting Soviet agricultural biologists.

A Committee on Soil Zoology was formed at the conference (as a part of the Third Commission of the All-Union Society of Soil Scientists, in accordance with the structure of the International Society of Soil Scientists).

The next or second conference on soil zoology will be held in Kiev in 1961.

OBITUARY

IKOLAY ALEKSANDROVICH DIMO

On March 15, 1959, following a serious illess, an outstanding scientist died — soil scintist and agronomist, active member of the ASKhNIL,[1] Doctor of Geological and Minerlogical Sciences, Director of the Soil Institute, Moldavian Branch), Academy of Sciences, SSR, and Head of the Department of Soil cience at Kishinev State University — Professor ikolay Aleksandrovich Dimo.

On the 30th of November, 1958, the scienfic community of our country observed the 5th birthday of Nikolay Aleksandrovich and ommemorated his 60 years of scientific, edagogical, and public service.

N. A. Dimo began his first scientific investiations at the end of the last century under the irection of V. V. Dokuchayev and N. M. Sibirsev, and to the end of his life he was full of nergy and creative plans. All his efforts were irected towards applying the achievements of oil science to various branches of the vigorusly developing socialistic agriculture of our ountry.

During his 60 years of work, N. A. Dimo oncerned himself with many problems of soil cience. More than 200 publications can be tributed to him, and he compiled dozens of oil maps of various scales for many areas.

The basic scientific activities of N. A. Dimo eparted as follows:

1. The soil geography of various districts our country (chernozem and forest-steppe ones within the former Saratov, Penza, and hernigov provinces; the Caspian lowland; entral Asia; and Transcaucasia).

In 1899 Dimo began detailed and systematic oil studies of the former Saratov province. dapting and perfecting a research methodology eveloped by Dokuchayev and his students in Nizhegorod and Poltava provinces, Dimo investigated the natural history of Saratov province. He gradually advanced from field surveys to basic research studies at permanent stations. In all, soil maps of every district (at a scale of 3 versts to the inch) were compiled either by N. A. Dimo or under his direction (by I. A. Shul'ga, T. P. Gordeyev, and others). These maps, which revealed the basic patterns of soil geography of the area, were original, enlightening, and superior in observation technique. A valuable feature of the maps was the designation of arable soils.

In 1908 he published the great work, Geographical sketch and classification of the soils of Saratov province. Here for the first time in our scientific literature were disclosed the geographical patterns of the gray forest soils, chernozems, chestnut soils and solonetz complexes; moreover, the conditions under which transitions from one to another occurred in the vast expanse of southern Volga region were determined.

From 1909, N. A. Dimo headed a large group of scientific workers who conducted soil and other natural-history surveys in the former Penza and Chernigov provinces. Among these workers were: geologists A. D. Arkhangel'skiy, G. F. Mirchink, and F. P. Savarenskiy; geographers L. S. Berg and A. A. Borzov; the botanist I. I. Sirygin; and soil scientists I. A. Shul'ga, V. V. Gemmerling, M. M. Filatov, A. M. Porubinovskiy, and others.

Along with other important workers, N. A. Dimo began a systematic survey of the soils of Central Asia in 1908. The basin of the Syr-Dar'ya and Amu-Dar'ya Rivers received special attention because of the development of cotton crop and the need to work out basic principles for irrigation. After the October Revolution Dimo continued these surveys, using an unusually large scale. By this time he was permanently employed in Tashkent at the Turkestan (now Central Asian) State University, which was created according to the instructions of V. I. Lenin. His part in organizing this first institution of higher education in Central Asia was exceptionally valuable. From 1920 to 1921 he was its head, and during the ten years up to 1931 he directed the Faculty of Agronomy, the Department of Soil Science, and the Scientific Research Institute of Soil Science and Geobotany. The last of these positions was of the greatest importance in the development of soil studies in Central Asia.

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[1] All-Union V.I. Lenin Academy of Agricultural iences.

N. A. Dimo surveyed the soils of Central Asia with the help of his students, among whom were M. N. Voskresenksiy, K. M. Klavdiyenko, M. A. Orlov, and A. N. Rozanov.

Soil maps at various scales of almost all the districts of Central Asia were compiled by Dimo. Two maps were especially interesting: his composite soil map of all Central Asian republics, at a scale of 1:1,000,000 (1927), which was displayed at the First International Congress of Soil Scientists in Washington; and his first soil map of Turkmeniya.

His works on the division of Central Asia into natural-history districts were of great practical value, as was his detailed estimate of the land resources available for both dry and irrigated farming. In addition, he drew attention to the cultivated soils of oases, remarking how they differed from the zonal sierozem soils of this area. He was the first to determine that the progressive increase in the amount of clay in oasis soils was the result of 1) silting caused by irrigation water and 2) intensive chemical weathering in soil formation.

N. A. Dimo did much to increase the understanding of Transcaucasus soils (1932-1944). He helped to resolve the Kura-Araksin problem, and studied in detail the soils of Northern Mugana in Azerbaydzhan and the Kolkhida lowland.

2. Soil and Vegetation Complexes. While he was still working in Saratov province, Dimo and the famous botanist B. A. Keller ascertained for the first time in scientific history the character and patterns of the soil and vegetation complexes found in the Caspian Sea lowland. Their widely known joint work, In the semidesert region, was the product of this important investigation (1907).

N. A. Dimo developed methods of mapping soil complexes both at scales previously used and at completely new ones: at very large scales or at "super scales," for example in scales ranging from 1:1,000 to 1:336 and even larger. He also proposed (and it was later adopted) the general use of a method of compiling soil-geomorphological profiles based on instrumental leveling.

The council of Novo-Aleksandriyskiy University of Agriculture and Forestry valued highly the monograph In the semidesert region and awarded the author its first N. M. Sibirtsev prize. B. B. Polynov wrote that "the appearance of this book was an exceptionally great eve in our science and at once elevated N. A. Dimo into the ranks of leading scientists."[2] In fact, the data and conclusions of this work are still very widely used both for soil, botanical, and geological studies and in large-scale soil and botanical surveys. In 1953 Dimo published his great work, The complexity and discontinuity of soils on the right side of the Alazani valley.

3. Saline soils. Saline soils, their classification and geographical distribution had received little attention before Dimo's studies. No strict distinction had even been made between solonetz and solonchak soils. In his study of the soils of Saratov province (especially in the former Tsaritsyn district, in the vicinity of Sarepta), a large and varied amount of material was collected describing salinization phenomena. The soil portion of the book In the semidesert region was filled with analytical data on water-soluble substances unusual for that time, and this explained a number of problems concerning dynamics and salt movement in saline soils. Then followed the richest addition to literature on the saline soils of Central Asia. Dimo's well-known summary report, Principal groups of soil and subsoil salinization in Russia (1914), was the result of many years of work on saline soils. Here a sharp distinction was made between solonetzes and solonchaks; the variety of these and other soils were described; the geographic (zonal) distribution patterns in Russia of the various types of saline soils were determined; and a nomenclature preserved to this day was proposed for them (for example, columnar, crusty solonetzes, etc.). Also examined were method for improving saline soils, and the salt tolerance of a number of crop plants.

Of considerable importance was N. A. Dimo' pioneering investigation of the quantitative salt balance in the plant-soil-subsoil-ground water system; in this study he used very deep soil profiles. First performed on Golodnaya steppe soils, this complicated investigation was repeated by Dimo later when studying saline soils of the Muganskaya steppe in Azerbaydzhan and the Alazani lowland in Georgia. These studies were of great value not only to soil science theo but also to the practice of saline-soil melioration in Azerbaydzhan, Georgia, and other districts of the country rich in saline soils.

4. Soil biology. N. A. Dimo pioneered in the organizing of many soil zoology investigations; he brought to light the soil-forming role of ants, termites, earthworms, desert lice, and small vertebrates. Moreover, he develope

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[2] Pochvovedeniye, 1948, No. 12, p. 708.

riginal methods of estimating the numbers and vork" of various soil organisms.

Earthworms in Central Asian soils (1938) of great interest. In it the soil-fertility alue of worms is clearly shown, and the de-endence of the earthworm population on the egree of soil cultivation is determined.

N. A. Dimo was a resolute opponent of the ewpoint that deserts and desert soils are lackg in life. By a number of examples he con-ncingly demonstrated that desert soils are ll of living things, and that the biological fac-r plays a considerable role in desert-soil rmation.

At the present time Dimo's biological works e available in a summary collection entitled bservations and investigations of soil fauna ishinev, 1955).

5. Study of the soils of Moldavia. Upon eturning to his homeland in Moldavia in 1945, ter a long absence, N. A. Dimo organized a mber of soil institutions — the Chair and epartment of Soil Science at Kishinev State niversity, and the Division of Soil Science ow the Soil Institute) of the Moldavian Branch the Academy of Sciences, USSR. A large ils staff and laboratory were also created at e Ministry of Agriculture of the Moldavian SR.

It must be remarked that, until 1945, the ate of knowledge of the soils of densely popu-ted Moldavia was at an extremely low level. detailed soil surveys had been conducted ere. These, however, were essential: the epublic has extremely varied soils and prac-ces many forms of agriculture, of which such anches as viticulture and horticulture have eat individual importance.

At the present time 400 Moldavian kolkhozes ve already received detailed soil data of a 10,000 scale. On the basis of these data the il Institute of the Moldavian Branch has been mpiling composite soil maps at 1:50,000, th sketches of all 40 administrative districts Moldavia. N. A. Dimo directed all this work. eginning in 1946 he published a series of arti-es dealing with the soils of Moldavia; in 1958 s work, Soils of Moldavia, their problems of udy and principal features, was published in separate edition. In it, drawing upon the eat amount of material obtained during his ry last years, Dimo described the specific atures of Moldavian forest soils, particularly e chernozems. He came to the conclusion at it was necessary to distinguish a separate oldavian soil province geographically wider than the boundaries of the republic.

Dimo's range of scientific interests was not restricted to the subjects mentioned previously. He investigated the physical properties of soil and methods for studying them; and he wrote several articles on the history of science, among which V. V. Dokuchayev — organizer of the university (1946) is particularly interesting.

N. A. Dimo is also known as a designer and inventor. In 1940 he proposed construction of a combine for creating a cultivated layer on stony soils. Until recently he worked successfully with N. N. Koz'yakov on a special machine for deep chiseling of soil.

Dimo did much for Soviet higher education. As early as 1920 he was drawn by Academician O. Yu. Shmidt to re-organize higher agricultural education. Two universities were created with the guiding participation of N. A. Dimo — the Central Asian (1920) and Kishinev (1946) — and, in both, soil and agronomical sciences occupied a worthy position.

During the Great October Revolution N. A. Dimo fulfilled the responsible mission of commanding the Transcaucasian and North Caucasian front.

The public service of N. A. Dimo was broad and many-faceted. Up to the last days of his life he was a deputy and member of the Presidium of the Supreme Soviet of the Moldavian SSR.

For his great services, Dimo was awarded the Order of Lenin, two orders of the Red Banner of Labor, the V. V. Dokuchayev gold medal, medals "For the defense of the Caucasus," "For victory over Germany," and other government medals.

Such is the brief and undoubtedly incomplete outline of the outstanding scientific activity of N. A. Dimo.

Death removed from the ranks of Soviet soil scientists the beloved Nikolay Aleksandrovich Dimo, a remarkable man and scientist, until the last hours of his life full of enthusiasm and creative plans, who gave all his strength for the good of our great socialist fatherland.

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REVIEW

PRACTICAL LABORATORY EXERCISES IN SOIL SCIENCE. 1957

L. N., ALEKSANDROVA and O. A. NAYDENOVA

This manual of practical laboratory exercises in soil science for agricultural colleges was published by Sel'khozgiz in 1957 (10,000 copies). The issuing of such a manual is quite justifiable and timely. The manual is applicable to the course program in soil science for agricultural colleges and covers all practical student work; it begins with laboratory exercises and concludes with field-training practice. This book compares favorably with similar, previously published manuals, in which the authors generally limited themselves to explaining laboratory methods for investigating soils. To the book's credit, the authors preface each new section covering a group of analyses designed to characterize some soil property with a short theoretical explanation entitled "General concepts."

Besides giving a positive appraisal of the book, we must mention certain real shortcomings. There is no clear, unified system for explaining the material on each student laboratory exercise. When beginning a soil analysis, the student must know why the given analysis is performed, the nature of the method to be used, and the step-by-step determination procedure including the most convenient form for recording the analytical data.

In our opinion, material on each analysis should be presented in the following form: 1) value of the analysis; 2) principle (essence) of the method; 3) procedure; 4) record form; and 5) example of the calculation of the results of the analysis.

It must be kept in mind that the students of agricultural colleges must learn how to conduct analyses of the greatest practical value. Furthermore, the most rapid, simple to perform, and sufficiently exact methods of soil analysis must be employed. The manual does not entirely meet these requirements. Tedious methods are presented which cannot always be carried out even in agricultural colleges, not to mention under ordinary working conditions. To this category belong the determination of adsorption capacity and exchangeable cations of calcium and magnesium by the Gedroits method, particle-size analysis by the pipette method, etc.

In the manual much is said about the degree of solonetz formation in soils, but not one method of determining the adsorbed sodium in soil is provided. It seems to us that the gypsum (volumetric) method developed by I. N. Antipov-Karatayev and L. Ya. Mamayeva might have been given. It is never indicated under which conditions a given method is either applicable or inapplicable. This is relevant, for example, in the case of the Kappen method, by which the total adsorbed cations in the soil are determined.

When explaining the analysis of the water extract (page 63), mention is made of determining the potential (not the titration) acidity. This introduces confusion into the concept of the kinds of soil acidity, especially since on page 44 two basic forms of acidity are spoken of: active and potential (including exchangeable and hydrolytic). On page 92 the specific gravity of soil (solid phase) is defined to be the weight of 1 cm^3 of solid particles of dry soil. It would have been more accurate to define the specific gravity of the solid phase of the soil as the ratio of the weight of a definite volume of solid particles of soil to the weight of water in the same volume (at 4°C). Such a definition of the specific gravity of soil follows from the very analytic procedure given in the book.

There are errors or misprints in the book. On page 16 the weight of 1 ml of CO_2 at 0°C and 760 mm (atmospheric pressure) is given to be 1.872 mg, which does not agree with what is presented in the table on page 18. On page 59 it is said that a 0.005% concentration of soda (Na_2CO_3) causes plants to die, while on page 145 this concentration is given as 0.05%.

It is to be hoped that in a succeeding edition of the book the section on basic methods of gravmetric, volumetric, and colorimetric analysis will be presented at the beginning of the book. This section should be supplemented by informaion about the preparation of percent solutions.

In spite of the defects indicated, the manual will undoubtedly be a useful guide for students of agricultural colleges.

Reviewed by I. Noll'

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